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Country Economics Department
The World Bank
February 1990
WPS 334

WPS 334

# An Econometric Method for Estimating the Tax Elasticity and the Impact on Revenues of Discretionary Tax Measures

## (Applied to Malawi and Mauritius)

Jaber Ehdaie

The author develops an econometric technique that deals with shortcomings of existing methods for estimating the tax elasticity and the impact on revenues of discretionary tax measures. He applies this model to Malawi and Mauritius to highlight the roles that discretionary tax measures and economic growth play in effecting the shift from the taxation of international trade to the taxation of domestic transactions.

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This paper — a product of the Public Economics Division, Country Economics Department — is part of a larger effort in PPR to study the fiscal aspects of structural adjustment. It proposes a method for estimating the additional revenues that might be mobilized within the existing tax system as GDP grows. Copies are available free from the World Bank, 1818 H Street NW, Washington DC 20433. Please contact Ann Bhalla, room N10-059, extension 37699 (90 pages with figures and tables).

In reducing the fiscal deficit as part of structural adjustment programs, it is important to be able to project what additional revenues can be mobilized within the existing tax system as GDP grows.

To know if it is necessary to generate more revenues — particularly through politically difficult discretionary tax measures — it is important to be able to estimate the built-in tax elasticity as percentage increases in tax revenue that result from endogenous increases in the base when GDP rises 1 percent.

Existing methods for estimating this elasticity are inadequate, so Ehdaie develops an econometric method for estimating built-in tax elasticity and the impact on revenues of discretionary tax measures.

His dynamic simultaneous-equation macroeconometric model of taxation captures the interaction between GDP, individual tax systems, and individual tax revenues and bases. It requires only time series data on tax revenues, tax bases, and GDP.

Ehdaie's model can also be used to (1) evaluate the macroeconomic impact of a tax reform program and (2) examine various tax-related economic issues.

In this paper, Ehdaie applies this model to the time series data for Malawi and Mauritius to highlight the roles that economic growth and discretionary tax measures play in effecting the shift from the taxation of international trade to the taxation of domestic transactions. His overall conclusions are:

- Discretionary tax measures have been effective in mobilizing resources from the private sector in both countries.

- Individual and overall tax revenues have been inelastic in connection with GDP — except for corporate income tax in Malawi and import tax in Mauritius, whose long-term elasticities exceed one. These two taxes are inelastic in terms of their own tax bases. Imports in Mauritius and value added in the nonagriculture sector in Malawi have grown faster than GDP.

- The domestic consumption tax had more built-in elasticity than import tax in Malawi; in Mauritius, the domestic consumption tax fell short of the import tax. Because of these structural differences, economic growth has fed the shift from taxing imports to taxing domestic transactions in Malawi; it has reversed the shift in Mauritius. Without economic growth, both countries would shift from taxing imports to taxing domestic transactions.

- In both countries, discretionary tax measures have contributed more to the trend toward domestic consumption tax than to the trend toward import taxes.

- In Malawi, economic growth and discretionary tax measures have played almost equal roles in the shift from taxing international trade to taxing domestic transactions. In Mauritius, economic growth has been the principal factor in reversing this shift.

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I am grateful to Javad Khalilzadeh-Shirazi, Jesús Seade, Pradeep Mitra, Wayne Thirsk, and William McCleary, who inspired me to undertake this study and provided useful comments. I am also thankful to Bela Balassa, Emmanuel Jimenez, Martha de Melo, P. Shome, Zmarak Shalizi and Anwar Shah for helpful comments.

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## CHAPTER I

## INTRODUCTION

The objective of this study is twofold: first, to develop an econometric method of estimating built-in tax elasticity and, hence, isolating the revenue impact of discretionary tax measures from that of economic growth; and second, to apply this model to selected Sub-Saharan Africa countries in order to highlight the contribution of discretionary actions taken by fiscal authorities to trends of tax effort and individual tax shares during the past two decades.[1]

The structural adjustment programs of developing countries use fiscal deficit reduction as one of the policy tools for achieving real economic growth with price stability and balance of payments viability. In dealing with this deficit within such a framework, projections need to be made of the additional revenues which can be mobilized within the existing tax system as GDP grows. These projections indicate the need to activate additional means of revenue generation, particularly politically difficult discretionary tax measures. Thus, it becomes essential to be able to estimate built-in tax elasticity (hereafter, tax elasticity) which measures

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1/ There are a variety of taxes, such as import tax, export tax, excise tax, sales/value added/turnover tax, corporate income tax and so on; throughout this study, the term "individual tax" will be used to refer to each of these taxes. Each tax has its own tax system--a set of laws and regulations governing the process of estimation, assessment and collection of its corresponding tax revenue--which will be called the "individual tax system". The term "discretionary tax measures (DTMs)" will be used to describe changes in these systems which include changes in statutory tax rates, tax bases, tax allowances and credits, and of tax administrative efficiency.

percentage increases in tax revenue resulting from the endogenous changes in the base caused by a one percent rise in GDP. However, its estimation by means of any of the existing methods suffers from a specification bias due to the lack of an observable quantitative variable capable of reflecting all changes in an individual (or overall) tax system in public finance.

There have been two major approaches employed by priori studies on this subject to deal with this gap. One approach has been, first, to eliminate discretionary tax changes from the historical time series tax data (HTSTD), and then to estimate tax elasticity using the adjusted HTSTD by means of the following single-equation econometric model.

$$\ln(T')_t = \mu_0 + \mu_1 \ln(Y)_t + \varepsilon_t \qquad (1)$$

where

$T'$ = adjusted HTSTD to discretionary tax changes,

$Y$ = tax base (or GDP in aggregate level),

$\varepsilon$ = disturbance term, and

$\mu_1$ = tax elasticity, defined as percentage increases in tax revenue net of discretionary tax changes due to one percent rise in the base (or GDP in aggregate level).

However, a complete adjustment of HTSTD to discretionary tax changes is impossible by means of any of the existing two major adjustment methods --proportional adjustment (PA) and constant rate structure (CRS) techniques.

In accordance with the proportional adjustment technique, the historical time series tax data are first adjusted to a preceding-year base.[2] This is done by subtracting the budget estimate of the revenue impact of DTMs implemented in a given year from the actual tax revenue collected in that year, that is,

$$T_{t,t} = T_t - D_t$$

where

$T_t$ = the actual tax revenue collected in the $t^{th}$ year,

$D_t$ = the budget estimate of the revenue impact (negative or positive) of the DTMs implemented in the $t^{th}$ year, and

$T_{t,t}$ = the actual revenue in the $t^{th}$ year adjusted to the structure of that year.

Then, to convert the $T_{t,t}$s to the first-year base, the adjusted tax revenue for the $t^{th}$ year ($T_{t,t}$) is multiplied by the previous year's ratio of the adjusted tax revenue according to the first year's structure ($T_{1,t-1}$) over the actual tax yield ($T_{t-1}$), that is,

$$(T')_1 = T_{1,1}$$

$$(T')_2 = \left[\frac{(T')_1}{T_1}\right] T_{2,2}$$

$$\vdots$$

$$(T')_t = \left[\frac{(T')_{t-1}}{T_{t-1}}\right] T_{t,t}$$

After making successive substitutions, the following formula is derived for $(T')_t$, which is in terms of $T_t$s and $D_t$s.

2/ This technique was first developed by Prest (1962). Later, Sahota (1961) employed a PA technique that, on the face of it, seemed different from Prest's method but yielded an identical result.

$$(T')_t = (T_t - D_t) \prod_{j=1}^{t-1} \left[ \frac{T_j - D_j}{T_j} \right] \qquad (2)$$

According to this method, changes in an individual tax system directly result in an exogenous change in its tax revenue, in other words, a shift in equation (1). These changes are, however, assumed not to affect its own and other individual tax bases endogenously, and thus, its consequences are not applied to the tax revenue. This is a strong assumption which is not supported theoretically[3] and its validity has not been tested empirically by any of the studies using this method.[4]

For example, an increase in the tariff on imports of consumption goods raises the price of these products ($P_m$) compared with that of competitive goods produced in the home economy ($P_d$), in other words, $P_m/P_d$. In an attempt to maximize their utilities, consumers will decrease and increase their demand respectively for the imported goods and domestic products. As a result, the import tax yield will decline due to the decrease in its base induced by an increase in its rate through the price mechanism. Domestic production of these products and/or their price will rise because of the increased demand, causing an increase in the companies' profit (corporate income tax base) and a rise in the potential base for taxes on domestic transactions, such as value added, turnover or sales tax. Consequently, the revenues stemming from the taxation of these sources will

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3/ This assumption is strongly rejected, at least by the studies which deal with the use of tariffs as a policy instrument to protect domestic industries, for example, see Balassa (1989).

4/ For examples, see Prest (1962), Mansfield (1972), Jeetun (1978), Sury (1985), Gillani (1986), Lambert and Suckling (1986) and Sahota (1961).

rise due to the increased tariff on imports of consumption goods (a change in other individual tax yields).

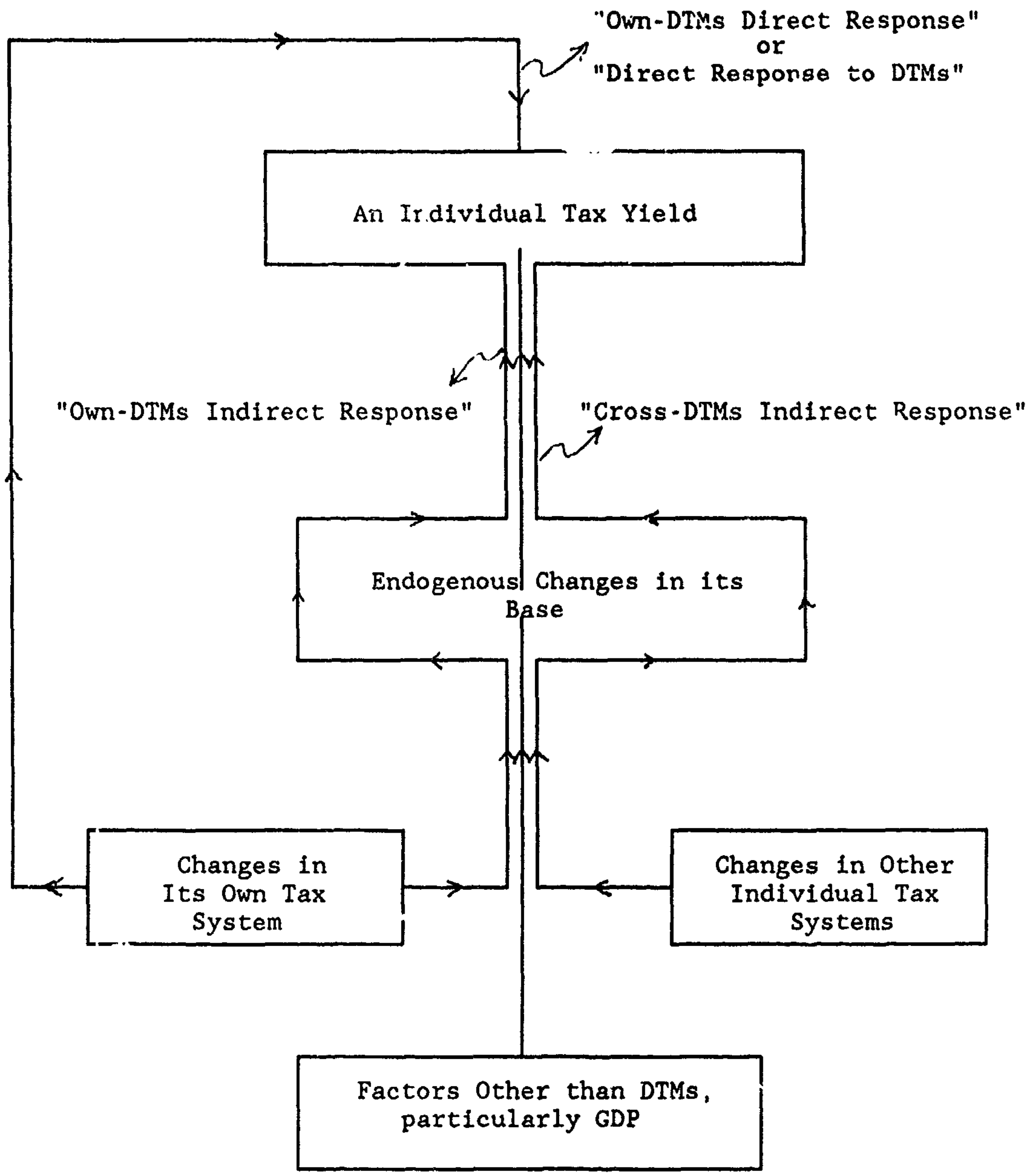
Similarly, the import tax revenue endogenously responds to changes in other individual tax systems. For instance, an increase in the income tax rate will reduce disposable income; private consumption will decline, including the consumption of goods imported from abroad. As a consequence, the import tax yield will fail because of the decrease in its base induced by a rise in the income tax rate through the income channel.

Figure 1 represents the decomposition of response of an individual tax yield to DTMs within this framework. It is apparent from this Figure that an individual tax revenue directly responds to changes in its own tax system ("own-DTM direct response") and to endogenous changes in its base. The base is endogenously influenced (i) by changes in its own and other individual tax systems through price mechanism, investment, savings and/or income channels, and (ii) by factors other than DTMs, particularly variations in GDP. Therefore, the tax revenue indirectly responds to changes in its own ("own-DTM indirect response") and other individual tax systems ("cross-DTM indirect response") through their impacts on its base.

More specifically, in the PA method, the own- and cross-DTM indirect responses of tax revenues are not incorporated in the process of the adjustment of HTSTD to discretionary tax changes. Furthermore, this method ignores the impact of changes in the degree of evasion or of administrative efficiency on tax revenues.

Finally, the PA method uses the budget estimates of discretionary tax changes ($D_t$s). Such data are difficult to obtain in many countries and,

FIGURE 1: Decomposition of Response of an Individual Tax Yield to Discretionary Tax Measures




"Indirect Response to DTMs"=sum of own- and cross-DTMs indirect responses.

if available, they are of questionable reliability as they differ substantially from actual discretionary outturns.

The CRS method requires data on income bracket (or commodity) rates and sufficiently disaggregated information on the growth and distribution of the reported tax bases.[5] If such disaggregated information is available, it would be possible to construct a constant rate-base series that would represent hypothetical yields under a system assumed to remain unchanged during the period under review as follows:[6]

$$(T')_t = \sum_{i=0}^{n} (\tau_i)_0 (X_i)_t \qquad (3)$$

where

$(\tau_i)_0$ = the base-year statutory tax rate on the $i^{th}$ income bracket (or commodity),

$(X_i)_t$ = the reported tax base in the $i^{th}$ income bracket (or commodity) in the $t^{th}$ year, and

$n$ = number of income brackets (or commodities).

It is revealed from equation (3) that the CRS method incorporates only the discretionary tax changes resulting from changes in statutory tax rates; thus, it ignores those discretionary tax changes which emerge from changes in administrative efficiency and in tax base, tax credit and tax allowances. Also, in this method, as in the PA technique, the own- and cross-DTM indirect responses of tax revenues are not taken into account in the process of the adjustment.

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5/ See Bahl (1972), Andersen (1973), Chelliah and Sheetal (1974) and Choudhry (1975).

6/ Chelliah and Sheetal (1974), PP. 12-13.

Furthermore, the needed information, particularly on the distribution of tax bases by rate categories, is not readily available; hence, the effective tax rates --defined as assessed tax revenue over the base-- of broad income classes (or commodity groupings) that are empirically used assume that interaclass (or interagrouping) distribution of the base will remain unchanged during the period under review. Naturally, the validity of this assumption will decline as the number of the income classes or commodity groupings in the breakdown falls due to aggregation.

Finally, Choudhry (1979) argues that the constant rate structure method becomes inefficient (P. 110), first, where a tax system has many progressive elements and, second, where tax bases grow at the same rates. Under the first circumstance, this method does not guarantee that the estimate of tax elasticity will be larger (or smaller) than that of tax buoyancy even when discretionary changes produce overall negative (or positive) revenue effects.[7] Under the second circumstance, there is the possibility that the elasticity estimate fails to detect the effects of discretionary changes.

Consequently, the adjusted HTSTD to discretionary tax changes by means of any of the existing methods (PA and CRS) involve measurement

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7/ Tax buoyancy measures percentage changes in tax revenue, including discretionary tax changes, due to a one percent increase in the base (GDP, in aggregate level). It is simply estimated by means of the following single-equation econometric model:

$$\log(T) = \alpha_0 + \alpha_1 \log(Y) + \varepsilon$$

where

$T$ = total tax revenue,
$Y$ = tax base, and
$\alpha_1$ = tax buoyancy.

errors which, in turn, create a specification bias in the estimate of tax elasticity.

The other approach has been to estimate tax elasticity directly from HTSTD using time trends or dummy variables as proxy for DTMs. Choudhry (1979) employs a divisia index (DI) method in which time trends are introduced as proxy for DTMs in the tax and base functions.[8] Briefly, this method involves three steps. First, a formula is derived which generates an index representing the revenue impact of DTMs. Second, the growth rate of this index is divided by that of the tax base; this ratio measures the growth rate of tax revenue resulting from DTMs in terms of a one percent increase in the base. Finally, tax elasticity is calculated by subtracting this ratio from the tax buoyancy.

Apart from the questionability of using time trends as representative of DTMs, the major empirical implication of this technique is that the formula derived in the first step is a line integral and, in practical application, its discrete version is used, causing bias in the estimate of the revenue impact of discretionary measures. The bias is downward (or upward) when the discretionary changes produce positive (or negative) revenue effects, resulting in an overestimate (or underestimate) of tax elasticity.[9]

Singer (1968), Chand and Wolf (1973), Khan (1973) and Artus (1974) use one dummy variable (simple or mixed) as proxy for each of the DTMs

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8/ This method is widely used in measuring the impact of changes in technology on the productivity of labor.

9/ For proof of this implication see Choudhry (1979), pp. 87-121.

taken during the period under review and they estimate tax elasticity by means of the following single-equation econometric model.

$$\ln(T)_t = \beta_0 + \beta_1 \ln(Y)_t + \sum_{i=1}^{n} \beta_{2i} D_i + U_t \qquad (4)$$

where

$T$ = tax revenue,

$Y$ = tax base or GDP in aggregate level,

$D_i$ = dummy variable (simple or mixed) as proxy for the $i^{th}$ DTM taken during the period under review, and

$\beta_1$ = tax elasticity; in aggregate level, it measures percentage increases in the tax revenue resulting from the endogenous changes in the base caused by a one percent rise in GDP.

However, the estimate of tax elasticity obtained by this technique is not precise and reliable because of the serious multicolinearity problem created as a result of entering more than one dummy variable into the tax function.[10] The degree of preciseness of and reliability on the elasticity estimate are inversely related to the degree of multicolinearity which, in turn, greatly depends on the time-interval that existed between two successive discretionary actions taken by fiscal authorities. For instance, the partial correlation coefficient of two dummy variables is 99 percent and 84 percent when the time-intervals are one year and five years respectively. This indicates that the degree of multicolinearity rises as the time interval between two successive DTMs falls, and it is still too

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10/ For more details on the impact of multicolinearity on the preciseness of the parameters estimates see G.S. Maddala (1977), pp. 183-190.

high even when the time interval is five years. This simply means that getting a precise and reliable estimate of tax elasticity by means of this technique is empirically impossible, particularly when there are frequent discretionary tax changes during the period under review.

Therefore, all the existing estimation methods of tax elasticity suffer from a specification bias which is mainly due to the lack of an observable quantitative variable capable of reflecting all changes in an individual (or overall) tax system in public finance. The primary objective of this study is to develop an econometric method of estimating tax elasticity and the revenue impact of DTMs which deals with this lack and, thus, with its consequences on the estimate of tax elasticity. Briefly, this method is a dynamic simultaneous-equation econometric model of taxation which captures the interaction of individual tax systems, individual tax revenues and bases and GDP. As representative of each individual tax system, its "average effective tax rate net of endogenous (built-in) changes in the tax yield and base" (AETRN) is introduced into the model. Time series data on AETRNs are automatically generated in the process of estimating the model parameters. The model explicitly incorporates both the direct and indirect responses of each individual tax revenue to changes in its own and other individual tax systems, i.e., own-DTM direct, own-DTM indirect and cross-DTM indirect responses. Its application requires only historical time series data on tax revenues, tax bases and GDP, all of which are already available for most countries.

In addition to its application as a method for estimating tax elasticity and the revenue impact of DTMs, this model can be used as an empirical framework:

(a) to forecast a government's revenue stemming from various sources of taxation;

(b) to evaluate the macroeconomic impact of a tax reform program which is aimed at either generating additional revenue and/or dealing with specific economic problems; and

(c) to deal with various tax related economic issues-- for example, to investigate the welfare impact of moving from differential tariffs towards uniform ones, which is often recommended by the Bank, or to examine the controversial view that uniform tariffs results in uniform rates of effective protection in industrial and non-industrial activities.

In this study, this model is used as an empirical tool to highlight the contribution of discretionary tax measures to trends of tax shares and tax effort in selected Sub-Saharan Africa countries during the 1965-85 period.

A shift from the taxation of international trade to the taxation of domestic transactions is recommended as one of the main objectives of an administratively feasible tax reform program in SSA countries, where such reform is often included in structural adjustment programs. The presumption, however, is that discretionary tax measures play a crucial role in effecting this shift. This description emerges from the experience of a number of Sub-Saharan Africa countries where tax effort has grown, the share of tax on domestic transactions in total tax revenue has risen and the import tax share has declined at least since the mid-1960s, though all three trends have halted or reversed since the late 1970s.[11]

11/ Shalizi and Squire (1988), P. 2.

However, discretionary tax measures have not been the only source of variation of tax shares; they have also been affected by endogenous changes in tax bases caused by factors other than these measures, particularly economic growth.

In SSA countries, fiscal authorities have taken a variety of discretionary actions in order to generate revenue and to deal with specific economic issues during the past two decades. In addition to their revenue generating objective, corporate income tax has been used to improve investment incentives and stimulate private sector investment in specific economic activities/regions; import tax has been applied as one of the policy instruments to protect infant domestic industries against competition of foreign ones; and domestic consumption tax has been utilized to deal with equity issues and cascading problems in the production chain.

During the same period, nominal and real gross domestic product have also grown, recording annual average rates of 13.4 percent and 2.6 percent respectively.[12]

Among the major economic sectors, non-agriculture (industry and service) has been the principal contributor to the overall economic growth; the share of its value added in GDP has increased from 61 percent in 1965 to 67.8 percent in 1985. This has been associated with the vertical and horizontal expansion of companies in this sector, resulting in endogenous changes in companies' net operating profit which is the potential corporate income tax base.[13]

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12/ The World Bank, World Development Report, (Oxford: Oxford University Press, 1987), PP. 16 & 173.

13/ Table 1 in Appendix A.

Expansion of the non-agriculture sector has been mainly due to sharp increases in domestic demand for consumption goods produced in this sector. This increase in demand has been influenced by a consumption goods import-substitution policy implemented by governments in order to industrialize the economy. So the share of consumption goods produced and consumed in the home economy (consumption tax base) in GDP has risen from 66 percent in 1965 to 78 percent in 1985; in the same period, the share of consumption goods imported from abroad in GDP has declined from 15 percent to 10 percent and that of other imports has grown slightly from 10 percent to 11 percent resulting in an annual average decrease of 0.20 percentage point in the share of total imports (import tax base) in GDP.

These historical observations indicate the interaction of economic growth with the trends of tax shares and efforts in SSA countries.

This study highlights the contribution that discretionary tax measures have made to the shift from the taxation of international trade to the taxation of domestic transactions in countries, such as Malawi, where such a shift has taken place. It also questions the effectiveness of these measures as a policy instrument for bringing about such a shift in other countries, like Mauritius, where the country's reliance on the foreign trade tax has risen during the past two decades. These are the tasks which have been neglected by previous studies and are addressed by this research.

The theoretical development of the model is discussed in Chapter II. To simplify its discussion, the model is disaggregated into three blocks--individual tax yield functions, individual tax base equations and identities. After discussing each block separately, the entire model as a method for estimating tax elasticity and the revenue impact of DTMs is represented, and its dynamic multipliers are derived. These multipliers measure the short run and long run impacts of economic growth and changes in each individual tax system on tax revenues and bases.

The application of the model to Malawi and Mauritius is discussed in Chapter III which consists of two sections. In the first section, the estimation method and results are discussed and the dynamic multipliers of the model are derived. Using these results, the contribution of discretionary tax measures to trends of tax effort and shares is analyzed in the second section. Briefly, the econometric application of the model to these countries yields a number of interesting results. For instance, it shows that: (i) discretionary tax measures have been an effective policy instrument in mobilizing resources from the private sector to the public sector, to the extent that tax effort would fall in the absence of DTMs; (ii) individual and overall tax revenues have been inelastic with respect to GDP, except corporate income tax in Malawi and import tax in Mauritius; (iii) economic growth and discretionary tax measures have had almost equal roles in shifting from the taxation of international trade to the taxation of domestic transactions in Malawi, contributing respectively 51 percent and 49 percent to the overall growth rate of domestic consumption tax-import tax; and (iv) in Mauritius, economic growth has been the principal factor in reversing this shift, to the extent that the country would shift from the taxation of international trade to the taxation of domestic transactions in the absence of nominal economic growth.

Finally, a summary of findings and suggestions for further research is presented in Chapter IV.

# CHAPTER II

## THEORETICAL DEVELOPMENT OF THE MODEL

It is revealed from Figure 1 that changes in an individual tax revenue directly result from changes in its own tax system and/or "endogenous changes" in its base. Its base is endogenously affected (i) by changes in its own and other individual tax systems through price mechanism, investment, savings or income channels, and (ii) by factors other than DTMs, particularly variations in GDP. In other words, individual tax systems, individual tax bases and yields and GDP are all interrelated. Their interaction is modelled in this chapter in order to estimate (a) the direct and indirect responses of each individual tax yield to changes in its own and other individual tax systems, and (b) elasticities of individual tax yields, individual tax bases and overall tax revenue with respect to GDP.

The concept of "tax elasticity" is defined to measure percentage increases in the tax revenue resulting from the endogenous changes in its base caused by a one percent rise in GDP. It is the product of elasticities of the tax yield to its base and the base to GDP.

Regarding the second objective of this research, all individual taxes are classified into five major categories. These are: (1) corporate income tax, (2) other direct taxes (individual income tax, social security, payroll tax, tax on property and other taxes on net income and profits), (3) import tax ( tariff/customs duties and other charges), (4) tax on exports, and (5) tax on domestic consumption (general sales, turnover or value added taxes, selective excises on goods and services, taxes on use of goods or property and permission to perform activities, stamp tax and other domestic indirect taxes).

To simplify this discussion, the model is disaggregated into three blocks--individual tax revenue equations, individual tax base functions, and identities. First, each of these blocks is separately discussed; then, the entire model as an empirical framework for estimating tax elasticity and the revenue impact of DTMs is discussed.

## Individual Tax Revenue Equations Block

As explained above, an individual tax revenue is directly affected by changes in its own tax system and its base. To separate out the direct revenue impacts of these two factors, each individual tax revenue assessed by tax inspectors ($T_i^*$) is considered to be a function of two proxy variables, one for its potential tax base ($X_i$) and another as representative of its own tax system ($\tau_i$), that is,

$$\log(T_i^*)_t = \alpha_{i0} + \alpha_{i1}\log(X_i)_t + \alpha_{i2}(\tau_i)_t + \varepsilon_{it} \qquad (1)$$

where

$\varepsilon_i$ = disturbance terms as representative of other explanatory, variables excluded from the model,

$i$ = d, tax on domestic transactions,

= m, tax on imports,

= x, tax on exports,

= c, corporate income tax, and

= o, other direct taxes.

This function was specified in semi-log-linear form essentially for a reason of convenience, that is, it allows a direct estimate of tax elasticity which is the primary objective of this research; furthermore, this is also a preferred functional form used in the previous studies.[1] Its generalized version is, however, discussed in appendix B.

Given a discrepancy between the assessed and actual tax revenue, tax inspectors will adjust the actual tax yields toward their assessed level. This adjustment process is not, however, completed instantaneously. Using a partial adjustment method, let us assume that they adjust actual individual tax revenues, $(T_i)_t$, toward their assessed level, $(T_i^*)_t$, by adding a fraction of the difference between the assessed tax yield, $(T_i^*)_t$, and the actual tax revenue of previous period, $(T_i)_{t-1}$, to the actual tax revenue collected in the previous period, $(T_i)_{t-1}$. This adjustment mechanism is written in its log-linear form as follows:

$$\Delta\log(T_i)_t = \lambda_i[\log(T_i^*)_t - \log(T_i)_{t-1}] \qquad (2)$$

where

$\lambda_i$ denotes the coefficient of adjustment of the $i^{th}$ individual tax yield, and $1 > \lambda_i > 0$.

The average time lag of the adjustment of the $i^{th}$ individual tax revenue is $(1-\lambda_i)/\lambda_i$, measuring the average period of time needed by tax inspectors to complete inspection of the tax files related to the $i^{th}$ individual tax.

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1/ For examples, see Mansfield (1972), Khan (1973), Artus (1974) and Chelliah and Sheetal (1974).

By substituting (2) in (1), actual individual tax revenue function is derived, that is,

$$\log(T_i)_t = \lambda_i\alpha_{i0} + \lambda_i\alpha_{i1}\log(X_i)_t + (1-\lambda_i)\log(T_i)_{t-1} + \lambda_i\alpha_{i2}(\tau_i)_t + U_{it} \quad (3)$$

where

$U_{it} = \lambda_i\varepsilon_{it}$, stochastic term.

Estimating parameters of this equation, however, requires the specification of proxy variables for the potential tax bases--time series data on these bases are not available in most developing countries--and the definition of $\tau_i$, an observable quantitative variable as representative of the $i^{th}$ individual tax system.

Specifying proxy variables for potential tax bases is straightforward. For instance, regarding the data availability and tax structure in SSA countries, Skinner (1988) considers respectively private consumption ($X_d$), imports ($X_m$), exports ($X_x$), value added in the non-agriculture sector ($X_c$) and gross domestic product ($X_o$) as proxy for the potential bases of domestic consumption tax ($T_d$), import tax ($T_m$), export tax ($T_x$), corporate income tax ($T_c$) and other direct taxes ($T_o$).

However, it has been the lack of an observable quantitative variable as representative of an individual (or overall) tax system in public finance which has complicated the issue of estimating individual and overall tax elasticities discussed in the previous chapter. To deal with this gap, this study defines $\tau_i$ as follows:

$$(\tau_i)_t = [R_i/X_i^*]_t \quad (4)$$

where

$(R_i)_t$ = the $i^{th}$ individual tax yield at time "t" net of the changes caused by endogenous changes in its base during the first year through the $t^{th}$ year of the period under review, and

$(X_i^*)_t$ = the $i^{th}$ individual tax base at time "t" net of endogenous changes during the first year through the $t^{th}$ year of the period under review.

It is revealed from this definition that value of $\tau_i$ in a given year, say "t", represents the average effective tax rate of the $i^{th}$ individual tax in that year in the absence of endogenous changes in its base and in its tax yield during the first year through the $t^{th}$ year of the period under review. Therefore, $\tau_i$ directly reflects all changes in the $i^{th}$ individual tax system which are the only source of its variations.

However, $\tau_i$ is not an observable variable because time series data on $X_i^*$ and $R_i$ are not available. This study derives a formula for each of these variables and, hence, for $\tau_i$ in terms of the observable variables and parameters included in the model, whose substitution in equation (3) generates an individual tax equation with estimable parameters.

Let $g_{it}$ denote percentage endogenous changes in the $i^{th}$ individual tax base during the first year through the $t^{th}$ year of the period under review--on which time series data are endogenously generated within the model proposed to be developed in this chapter (see tax base functions block). Using $g_{it}$s, the $i^{th}$ individual tax base ($X_i$) is decomposed into two separable parts in terms of its two major sources of variation mentioned above, that is,

$$(X_i)_t = (X_i^*)_t(1 + g_{it}) \qquad (5)$$

$(X_i^*)_t$ is that part of $(X_i)_t$ which is exogenously affected by changes in its potential tax base made by fiscal authorities and $(1+g_{it})$ is that part of $(X_i)_t$ which is influenced by the factors resulting in endogenous changes in $(X_i)_t$.

By solving equation (5), the following formula is obtained for $X_i^*$

$$(X_i^*)_t = [(X_i)_t / (1+g_{it})] \qquad (6)$$

According to the definition of $\tau_i$, its coefficient in equation (3), $\lambda_i\alpha_{2i}$, measures the direct response of the $i^{th}$ individual tax to DTMs (own-DTM direct response), and the coefficient of $X_i$, $\lambda_i\alpha_{1i}$, measures its response to the endogenous changes in its base--percentage changes in $T_i$ due to a one percent endogenous increase in $X_i$ (elasticity of $T_i$ with respect to $X_i$). Using $\lambda_i\alpha_{1i}$s, each individual tax yield can be decomposed into two separable parts in terms of its two major sources of variation--these are changes in its own tax system and endogenous changes in its tax base--as follows:

$$(T_i)_t = (R_i)_t(1 + \lambda_i\alpha_{i1}g_{it}) \qquad (7)$$

where

$\lambda_i\alpha_{i1}g_{it}$=the percentage changes in the $i^{th}$ individual tax yield during the first year through the $t^{th}$ year of the period under review which result from $g_{it}$ percent endogenous change in its base taken place throughout the same period.

$R_i$ is that part of $T_i$ which is directly affected by changes in the $i^{th}$ individual tax system, which is the only source of its variation; its value at any point of time, say "t", represents the amount of the tax yield collected from the $i^{th}$ individual tax source at that time in the absence of endogenous changes in its tax base during the first year through the $t^{th}$ year of the period under review. Changes in $T_i$ resulting from endogenous changes in its base are realized through $(1+\lambda_i \alpha_{i1} g_{it})$.

By solving equation (7), the following formula is derived for $R_i$.

$$(R_i)_t = [(T_i)_t / (1 + \lambda_i \alpha_{i1} g_{it})] \qquad (8)$$

Now, by substituting (6) and (8) in (4), the following formula is obtained for $\tau_i$, which is in terms of the parameters and observable variables included in the model proposed to be developed in this study.

$$(\tau_i)_t = \frac{\dfrac{(T_i)_t}{(1 + \lambda_i \alpha_{i1} g_i)_t}}{\dfrac{(X_i)_t}{(1 + g_i)_t}} = \left[ (r_i)_t \, \frac{(1 + g_i)_t}{(1 + \lambda_i \alpha_{i1} g_i)_t} \right] \qquad (9)$$

where

$(r_i)_t = (T_i / X_i)_t =$ average effective individual tax rate.

In accordance to equation (9), in fact, $\tau_i$ is the ratio of the $i^{th}$ individual tax yield ($T_i$) deflated by the index of that part of the tax revenue gained from endogenous changes in its base, $(1+\lambda_i\alpha_{i1}g_i)$, over its base $(X_i)$ deflated by the index of that part of the base which is not directly affected by changes in its potential base made by fiscal authorities, $(1+g_i)$.

Substituting (9) in (3) produces the following equation with estimable parameters for individual tax yields.

$$\log(T_i)_t = \lambda_i\alpha_{i0} + \lambda_i\alpha_{i1}\log(X_i)_t + (1-\lambda_i)\log(T_i)_{t-1} + \lambda_i\alpha_{i2}\{r_i[(1+g_i)/(1+\lambda_i\alpha_{i1}g_i)]\}_t + \lambda\varepsilon_{it} \quad (3)'$$

where

$\lambda_i$ = coefficient of adjustment,

$\alpha_{i1}$ =long-run elasticity of $T_i$ with respect to $X_i$

$\lambda_i\alpha_{i1}$=short-run elasticity of $T_i$ with respect to Xi,

$\lambda_i\alpha_{i2}$=percentage changes in $T_i$ due to one percentage point increase in $\tau_i$ (own-DTM direct response) in the short-run

$\alpha_{i2}$ =percentage changes in $T_i$ due to one percentage point increase in $\tau_i$ (own-DTM direct response) in the long-run.

Equation $(3)'$ is non-linear in both parameters and variables. It is exact identified. Its parameters can be estimated by means of a non-linear econometric estimation method. After estimating its parameters, time series data on $\tau_i$s are generated by means of equation (9) using a simulation technique. These data can be used independently to deal with various tax related economic issues.

Equation (3), for i=d, m, c, x, and o, stands for the individual tax yield functions block of the model. Estimates of its parameters are obtained by estimating parameters of equation (3)$'$.

If the specified proxy variables for potential tax bases are not exogenously affected by discretionary changes in potential tax bases (or there have not been any discretionary changes in these tax bases during the period under review), historical time series data on $X_i$s can be used to generate time series data on $g_i$s. However, in the theoretical framework, each individual tax base ($X_i$) is linked to its own as well as other individual tax systems ($\tau_i$s) through various economic channels--that is, the impact of changes in $\tau_c$ and $\tau_o$ on individual tax bases are realized through investment, savings and/or income channels, and that of changes in $\tau_m$, $\tau_d$, and $\tau_x$ are recognized through the price mechanism. This link may empirically result in a high degree of linear correlation between $X_i$ and $\tau_i$ in equation (3) as a <u>single-equation</u> econometric model, thereby reducing the degree of preciseness and reliability of the estimate of its parameters and, hence, of the generated time series data on $\tau_i$s.

Fortunately, this econometric issue is not a multicolinearity problem which is a feature of the sample; it is a simultaneity issue which can be easily overcome by expanding the single-equation econometric model, in other words, equation (3), to a simultaneous-equation model in which individual tax base functions become an integral part of it.

Having defined $\tau_i$s as observable proxy variables representing individual tax systems, the development of individual tax base equations is straight-forward.

## Individual Tax Base Equations Block

Unlike in the case of individual tax revenue equations, developing a single-functional form as representative of all individual tax base equations is impossible. Because, as explained above, there is not a single-economic channel through which changes in individual tax systems affect individual tax bases. For this, the development of each individual tax base equation is discussed separately, using as an example a country whose economic structure and tax system is similar to those of Sub-Saharan Africa countries. In particular, this means a country in which private consumption, imports, exports, value added in non-agriculture sector and GDP can respectively be used as proxy variables for potential tax bases of domestic consumption tax, import tax, export tax, corporate income tax and other direct taxes.

### Domestic Consumption Tax Base Function

Using a Keynsian approach, private consumption ($X_d$)--as a proxy variable for the potential base of tax on domestic transactions--is considered to be a function of disposable income ($Y_d$) defined as gross domestic product (GDP) minus total direct taxes ($T_c$+$T_o$). By entering $Y_d$ as an explanatory variable in this function, the impact of the DTMs related to direct taxes (changes in $\tau_c$ and $\tau_o$) on $X_d$ is explicitly taken into account. That is, any change in $\tau_c$ and/or $\tau_o$ directly affects $T_c$ and/or $T_o$ through equation (3), resulting in changes in disposable income and, hence, private consumption.

Consumers also react to the discretionary tax measures related to <u>indirect taxes</u> (changes in $\tau_m$ and $\tau_d$) through the price mechanism channel. For example, an increase in the tariff on imported consumption goods will raise the price of these products ($P_m$) compared with that of competitive products ($P_d$) produced in the home economy, in other words, $P_m/P_d$. In an attempt to maximize their utilities, consumers will increase their demand for the competitive products produced in the home country and decrease their demand for those imported from abroad. As a result, the potential base for the tax on domestic transactions will go up while the import tax base will fall.

Another explanatory variable, $(\tau_m/\tau_d)$, is entered into the consumption function in order to take into account the impact of the DTMs related to <u>indirect taxes</u> on $X_d$ explicitly. Obviously, the impact of that part of the changes in $P_m/P_d$ caused by the factors other than DTMs on $X_d$ is implicitly incorporated in the model by entering the nominal values of $X_d$ (private consumption net of $T_d$) and $Y_d$ in it.

The equation for this tax base is assumed to have the following functional form.

$$\ln(X_d)_t = \beta_{d0}\ \beta_{d1}\ln(Y_d)_t + \beta_{d2}(\tau_m/\tau_d)_t + \upsilon_{dt} \qquad (10)$$

where

$X_d$ = nominal private consumption at factor cost,

$Y_d$ = GDP - $T_c$ - $T_o$, nominal disposable,

$\beta_{d1} > 0$, elasticity of $X_d$ with respect to $y_d$,

$\beta_{d2} > 0$, percentage changes in $X_d$ due to one unit increase in $(\tau_m/\tau_d)$,

$\upsilon_d$ = disturbance terms as representative of the explanatory variables excluded from the model with standard classical assumptions.

By substituting equation (9) in (10), the domestic consumption tax base function with estimable parameters is derived, that is,

$$\ln(X_d)_t = \beta_{d0} + \beta_{d1}\ln(Y_d)_t + \beta_{d2}\left[\frac{r_m[(1+g_m)/(1+\alpha_{m1}g_m)]}{r_d[(1+g_d)/(1+\alpha_{d1}g_d)]}\right]_t + \upsilon_{dt} \qquad (10)'$$

<u>Import Tax Base Function</u>

Similarly, using the traditional approach to import function, the nominal value of imports net of import taxes--as a proxy for the import tax base--is considered to be a function of nominal GDP at factor cost, $(\tau_m/\tau_d)$ and $\tau_c$, that is,

$$\ln(X_m)_t = \beta_{m0} + \beta_{m1}\ln(GDP)_t + \beta_{m2}(\tau_m/\tau_d)_t + \beta_{m3}(\tau_c)_t + \upsilon_{mt} \qquad (11)$$

where

$X_m$ =nominal value of imports net of $T_m$,

GDP=nominal gross domestic products at factor cost,

$\beta_{m1} > 0$, elasticity of $X_m$ with respect to GDP,

$\beta_{m2} < 0$, percentage changes in $X_m$ due to a one percentage point increase in $(\tau_m/\tau_d)$,

$\beta_{m3} > 0$, percentage changes in $X_m$ due to a one percentage point increase in $\tau_c$,

$\beta_{m3}>0$, percentage changes in $X_m$ due to a one percentage point increase in $\tau_c$, and

$\upsilon_{mt}$=disturbance terms as representative of other sources of variation in $X_m$ resulting from the factors excluded from the model.

The import tax base function with estimable parameters is derived by substituting (9) in (11), that is,

$$\ln(X_m)_t=\beta_{m0}+\beta_{m1}\ln(GDP)_t+\beta_{m2}\left[\frac{r_m[(1+g_m)/(1+\alpha_{m1}g_m)]}{r_d[(1+g_d)/(1+\alpha_{d1}g_d)]}\right]_t+\beta_{m3}\frac{r_c(1+g_c)}{(1+\alpha_{c1}g_c)}+v_{mt} \quad (11)'$$

Corporate Income Tax Base Function

The impacts of changes in the corporate income tax system ($\tau_c$) and the variations in GDP on value added in the non-agriculture sector ($X_c$)--as representative of the potential base of corporate income tax--are realized through investment channels.[2] Any change in the corporate income tax system (say, a decrease in $\tau_c$) will affect (raise) the after-tax marginal rate of return to capital in this sector which will influence (enhance) the level of investment in the non-agriculture sector resulting in a change (an increase) in $X_c$.

Variations in GDP can also affect investment through the acceleration principle which, in turn, influences value added in the non-agriculture sector; that is, an increase (or a decrease) in GDP raises (or

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2/ Value added in the non-agriculture sector ($X_c$) is considered as a proxy for the potential base of corporate income tax due to the lack of time series data on the wage bill in this sector in most LDCs. However, in the countries where such time series data are available, the wage bill should be deducted from $X_c$.

reduces) aggregate demand, including demand for goods and services produced in the non-agriculture sector. As a result, investment in this sector rises (or falls), resulting in an increase (or a decrease) in $X_c$.

Consequently, $X_c$ is negatively related to $\tau_c$ and positively linked to gross domestic product. Its equation is assumed to have the following functional form.[3]

$$\ln(X_c)_t = \beta_{c0} + \beta_{c1}\ln(GDP)_t + \beta_{c2}(\tau_c)_t + \beta_{c3}(\tau_m/\tau_d)_t + \upsilon_{ct} \qquad (12)$$

where

$X_c$ =nominal value of value added in non-agriculture sector net of corporate income tax at factor cost,

$\upsilon_{ct}$=disturbance terms as representative of other sources of variation of $X_c$ resulting from the factors excluded from the model,

$\beta_{c1}>0$, elasticity of $X_c$ with respect to GDP, and

$\beta_{c2}<0$, percentage changes in $X_c$ due to one percentage point change in $\tau_c$.

Furthermore, the value added in the non-agriculture sector is linked to the DTMs related to indirect individual taxes (changes in $\tau_m$ and $\tau_d$) through price mechanism. For instance, a decrease in the tariff on the import of raw materials utilized in the non-agriculture sector will reduce

3/ Using Lewis' approach, labor as another factor of production has been dropped from this equation because there is an excess supply of labor in SSA countries, as in most LDCs. One may argue that there is a shortage of a skilled labor force in the non-agriculture sector. However, training unskilled labor, in turn, requires more investment; therefore, it is plausible to assume that the level of employment in this sector is highly dependent on the rate of capital formation rather than on other factors, and to drop it from equation 12.

the production cost and, hence, will raise the value added in this sector or an increase in the tariff on the import of industrial consumption goods will raise demand for competitive commodities produced in the home country resulting in a rise in production and, thus, an increase in $X_n$.

This study entered $(\tau_m/\tau_d)$ into equation (12) as another explanatory variable in order to capture the impact of the DTMs related to indirect taxes on $X_c$ directly. However, the sign of the coefficient of this variable $(\beta_{c3})$ will depend on the sizes of the estimates of $\beta_{m1}$ and $\beta_{d1}$, and the shares of $X_d$ and $X_m$ into GDP as well as on the structure of the import tax system and imports. For example, in the countries where imports of non-consumption goods are not subject to import tax, $\beta_{c3}$ will be positive if and only if $\beta_{c1}(X_c/GDP) > \beta_{m1}(X_m/GDP)$.

However, the ambiguity on the sign of $\beta_{c3}$ can be easily overcome by disaggregating import taxes into two major categories of imports, in other words, imports of consumption goods and other imports.

By substituting equation (9) in (12), the corporate income tax base function with estimable parameters is obtained, that is,

$$\ln(X_c)_t = \beta_{c0} + \beta_{c1}\ln(GDP)_t + \beta_{c2}(r_d[(1+g_d)/(1+\alpha_{d1}g_d)])_t + \beta_{c3}\left[\frac{r_m[(1+g_m)/(1+\alpha_{m1}g_m)]}{r_d[(1+g_d)/(1+\alpha_{d1}g_d)]}\right]_t + \upsilon_{ct} \qquad (12)'$$

<u>Export Tax Base Function</u>

The nominal value of exports net of export taxes as a proxy for an export tax base is simply considered to be a function of the weighted average of GDP of importer countries ($GDP_w$)--the weight for each importer country being the ratio of exports to this country over total exports--and $\tau_i$s. Its equation is assumed to have the following functional form.

$$\ln(X_x)_t = \beta_{x0} + \beta_{x1}\ln(GDP_w)_t + \sum_j[\beta_{xj}(\tau_j)_t] + \upsilon_{xt} \qquad (13)$$

where

$X_x$ =nominal export net of export taxes in terms of the exporter national currency,

$GDP_w$=weighted average of nominal GDP of the importer countries in terms of national currency of the exporter country,

$\beta_{x1}>0$, elasticity of $X_x$ with respect to $GDP_w$, and

$\beta_{xj}<0$, percentage changes in $X_x$ with respect to a one percentage point change in $\tau_j$, for j="x", "m", "d", "o" and "c".

After substituting equation (9) in (13), the following export tax base function with estimable parameters is derived.

$$\ln(X_x)_t = \beta_{x0} + \beta_{x1}\ln(GDP_w)_t + \sum_j\{\beta_{xj}[r_j(1+g_j)/(1+\alpha_{j1}g_j)]_t\} + \upsilon_{xt} \qquad (13)'$$

where

$(g_j)_t = \ln(X_j)_t - \ln(X_j)_1$, for j="m", "d", "x", "o" and "c".

As an another explanatory variable, the GDP of the exporter country was excluded from this equation for the following reason. Export tax is a consumption or rent type tax which is levied on the products exported to foreign countries. It is not a tax on the domestic production or domestic consumption of these goods. Therefore, the export tax base ($X_x$) is considered to be a function of the factors which affect the demand of foreigners for the exportable products, in other words, the GDP of importer countries, relative prices and $r_i$s. Indeed, the factors which influence domestic production or consumption of these products may affect $X_x$ through the price mechanism. Equation (13)′ implicitly incorporates the impact of such changes on $X_x$ because the nominal value of $X_x$ and $GDP_w$ are entered into that equation.

Since the primary objective of this study is to estimate individual and overall tax elasticities with respect to the GDP of the home country, the export tax revenue and base functions are excluded from the entire model as an empirical framework for estimating tax elasticity and the revenue impact of discretionary tax measures.

Equations (10), (11) and (12) perform the individual tax base functions block of the model. Estimates of their parameters are obtained by estimating the parameters of equations (3)′, (10)′, (11)′ and (12)′ by means of a non-linear simultaneous-equation econometric estimation method.

## Identities Block

Disposable income is the difference between GDP and direct taxes, that is,

$$(Y_d)_t = (GDP)_t - (T_c)_t - (T_o)_t \qquad (14)$$

All of the variables included in (14) appear in logarithmic form in the equations developed above--equations (3), (10), (11) and (12). For reasons of convenience, it is also transferred to a log-linear form as follows:

$$e^{\ln(Y_d)_t} = e^{\ln(GDP)_t} - e^{\ln(T_c)_t} - e^{\ln(T_o)_t} \tag{15}$$

Using Taylor's series, equation (15) is expanded around the geometric mean value of the variables included in it, that is,

$$\ln(Y_d)_t = \gamma_0 + \gamma_1 \ln(GDP)_t + \gamma_2 \ln(T_c)_t + \gamma_3 \ln(T_o)_t \tag{16}$$

where

$\gamma_0 = \ln(Y_d)^* - (GDP/Y_d)^* \ln(GDP)^* + (T_c/Y_d)^* \ln(T_c)^* + (T_o/Y_d)^* \ln(T_o)^*$

$\gamma_1 = (GDP/Y_d)^* > 0,$

$\gamma_2 = -(T_c/Y_d)^* < 0,$

$\gamma_3 = -(T_o/Y_d)^* < 0,$

and "*" denotes geometric mean value.

The total tax revenue net of export taxes is simply the sum of the other individual tax yields, that is,

$$(T)_t = (T_c)_t + (T_o)_t + (T_d)_t + (T_m)_t \tag{17}$$

Using the method mentioned above and expanding equation (17) around the geometric mean value of the variables included in it and then making a simple manipulation, this equation is converted to the following log-linear form which allows a direct estimate to be made of the automatic response of the overall tax system to variation in GDP:

$$\ln(T)_t = \delta_0 + \delta_c \ln(T_c)_t + \delta_o \ln(T_o)_t + \delta_d \ln(T_d)_t + \delta_m \ln(T_m)_t \quad (18)$$

where

$\delta_0 = \log(T)^* - \Sigma[(T_i/T)^* \log(T_i)^*$,

$\delta_i = (T_i/T)^* > 0$, and $i = c, o, d, m$.

Equations (16), (17) and (19) are deterministic functions whose parameters can be estimated either by using the mean value of time series data on the variables included in them or by the OLS estimation method.

## Entire Model And Its Dynamic Multipliers

Equations (3)--for i=c, d, m, o--, (10), (11), (12), (16) and (18) provide the structural form of the model developed in this study (Table 1). Efficient and consistent estimates of its parameters are obtained by estimating the parameters of equations (3)′, (10)′, (11)′, (12)′, (16) and (18) by means of a simultaneous-equation non-linear econometric estimation technique (Table 2).[4]

Using the estimated parameters, the time series data on $\tau_i$s are generated by means of equation (9). These data can be used independently to investigate the impact of changes in individual tax systems on various key macroeconomic variables, such as savings, inflation, investment, economic growth, international balance of payments, and so on. To simplify the derivation of the revenue impact of changes in each individual tax system

4/ There are four simultaneous-equation non-linear estimation methods. These are: three-stage non-linear least squares, iteration, search and maximum likelihood estimation techniques. For more details, see Maddala(1977), pp. 144-146; also Fair(1984) pp. 120-138.

Table 1: Structural Form of the Model

$$\log(T_d)_t = \lambda_d\alpha_{d0} + \lambda_d\alpha_{d1}\log(X_d)_t + (1-\lambda_d)\log(T_d)_{t-1} + \lambda_d\alpha_{d2}(\tau_d)_t + U_{dt}$$

$$\log(T_m)_t = \lambda_m\alpha_{m0} + \lambda_m\alpha_{m1}\log(X_m)_t + (1-\lambda_m)\log(T_m)_{t-1} + \lambda_m\alpha_{m2}(\tau_m)_t + U_{mt}$$

$$\log(T_c)_t = \lambda_c\alpha_{c0} + \lambda_c\alpha_{c1}\log(X_c)_t + (1-\lambda_c)\log(T_c)_{t-1} + \lambda_c\alpha_{c2}(\tau_c)_t + U_{ct}$$

$$\log(T_o)_t = \lambda_o\alpha_{o0} + \lambda_o\alpha_{o1}\log(X_o)_t + (1-\lambda_o)\log(T_o)_{t-1} + \lambda_o\alpha_{o2}(\tau_o)_t + U_{ot}$$

$$\ln(X_d)_t = \beta_{d0}\ \beta_{d1}\ln(Y_d)_t + \beta_{d2}(\tau_m/\tau_d)_t + \nu_{dt}$$

$$\ln(X_m)_t = \beta_{m0} + \beta_{m1}\ln(GDP)_t + \beta_{m2}(\tau_m/\tau_d)_t + \beta_{m3}(\tau_c)_t + \nu_{mt}$$

$$\ln(X_c)_t = \beta_{c0} + \beta_{c1}\ln(GDP)_t + \beta_{c2}(\tau_c)_t + \beta_{c3}(\tau_m/\tau_d)_t + \nu_{ct}$$

$$\ln(T)_t = \delta_0 + \delta_d\ln(T_d)_t + \delta_m\ln(T_m)_t + \delta_c\ln(T_c)_t + \delta_o\ln(T_o)_t$$

$$\ln(Y_d)_t = \gamma_0 + \gamma_1\ln(GDP)_t + \gamma_2\ln(T_c)_t + \gamma_3\ln(T_o)_t$$

$$(\tau_m/\tau_d)_t = \theta_0 + \theta_1(\tau_m)_t + \theta_2(\tau_d)_t$$

where

- $T_d$ = Tax on domestic transactions (endogenous variable),
- $T_m$ = Import tax (endogenous variable),
- $T_c$ = Corporate income tax (endogenous variable),
- $T_o$ = Other direct taxes (endogenous variable),
- $X_d$ = Private consumption (endogenous variable),
- $X_m$ = Imports (endogenous variables),
- $X_c$ = Value added in non-agriculture sector (endogenous variable),
- $X_o$ = GDP = gross domestic products (exogenous variable),
- $\tau_i$ = The $i^{th}$ individual realized tax rate (exogenous variable), for $i$ = d, m, c, o,
- $Y_d$ = Disposable income (endogenous variable),
- $T$ = Total tax revenue net of export taxes (endogenous variable).

Table 2: Entire Model with Estimable Parameters*

$$\ln(T_d)_t = \lambda_d\alpha_{d0} + \lambda_d\alpha_{d1}\ln(X_d)_t + (1-\lambda_d)\ln(T_d)_{t-1} + \lambda_d\alpha_{d2}\left[r_d \frac{1+g_d}{1+\lambda_d\alpha_{d1}g_d}\right]_t + \varepsilon_{dt}$$

$$\ln(T_m)_t = \lambda_m\alpha_{m0} + \lambda_m\alpha_{m1}\ln(X_m)_t + (1-\lambda_m)\ln(T_m)_{t-1} + \lambda_m\alpha_{m2}\left[r_m \frac{1+g_m}{1+\lambda_m\alpha_{m1}g_m}\right]_t + \varepsilon_{mt}$$

$$\ln(T_c)_t = \lambda_c\alpha_{c0} + \lambda_c\alpha_{c1}\ln(X_c)_t + (1-\lambda_c)\ln(T_c)_{t-1} + \lambda_c\alpha_{c2}\left[r_c \frac{1+g_c}{1+\lambda_c\alpha_{c1}g_c}\right]_t + \varepsilon_{ct}$$

$$\ln(T_o)_t = \lambda_o\alpha_{o0} + \lambda_o\alpha_{o1}\ln(X_o)_t + (1-\lambda_o)\ln(T_o)_{t-1} + \lambda_o\alpha_{o2}\left[r_o \frac{1+g_o}{1+\lambda_o\alpha_{o1}g_o}\right]_t + \varepsilon_{ot}$$

$$\ln(X_d)_t = \beta_{d0} + \beta_{d1}\ln(Y_d)_t + \beta_{d2}\left[\frac{r_m[(1+g_m)/(1+\alpha_{m1}g_m)]}{r_d[(1+g_d)/(1+\alpha_{d1}g_d)]}\right]_t + v_{dt}$$

$$\ln(X_m)_t = \beta_{m0} + \beta_{m1}\ln(GDP)_t + \beta_{m2}\left[\frac{r_m[(1+g_m)/(1+\alpha_{m1}g_m)]}{r_d[(1+g_d)/(1+\alpha_{d1}g_d)]}\right]_t + \beta_{m3}\frac{r_c(1+g_c)}{(1+\alpha_{c1}g_c)} + v_{mt}$$

$$\ln(X_c)_t = \beta_{c0} + \beta_{c1}\ln(GDP)_t + \beta_{c2}\left[r_d \frac{1+g_d}{1+\alpha_{d1}g_d}\right]_t + \beta_{c3}\left[\frac{r_m(1+g_m)/(1+\alpha_{m1}g_m)}{r_d(1+g_d)/(1+\alpha_{d1}g_d)}\right]_t + v_{ct}$$

$$\ln(T)_t = \delta_0 + \delta_d\ln(T_d)_t + \delta_m\ln(T_m)_t + \delta_c\ln(T_c)_t + \delta_o\ln(T_o)_t$$

$$\ln(Y_d)_t = \gamma_0 + \gamma_1\ln(GDP)_t + \gamma_2\ln(T_c)_t + \gamma_3\ln(T_o)_t$$

$$g(i)_t = \ln(X_i)_t - \ln(X_i)_0 \qquad \text{for } i=d,\ m,\ c,\ o$$

* Estimating the parameters of the model requires time series data on $T_i$s, T, $X_i$s, $r_i$s, and GDP which are readily available for most LDCs in GFS(an IMF publication) and World Tables (a World Bank publication).

from the estimated parameters of the model, this study uses the generated time series data on $\tau_i$s to linearize $(\tau_m/\tau_d)$ in order to keep the entire model in semi-log linear form. Its linear form is obtained by expanding it around the mean value of $\tau_i$s using Taylor's series, which is,

$$(\tau_m/\tau_d)_t = \theta_0 + \theta_1(\tau_m)_t + \theta_2(\tau_d)_t \qquad (19)$$

where

$\theta_0=(\tau_m/\tau_d)^* > 0$,

$\theta_1=(1/\tau_m)^* > 0$, and

$\theta_2=-[\tau_m/(\tau_d)^2]^* < 0$.

Equation (19) is a deterministic equation whose parameters can be estimated using either the mean value of the generated time series data on $\tau_i$s or the OLS estimation technique.

Consequently, the structural form of the model with estimated parameters will include ten equations--equations (3), for i=d, c, o, m, and (10), (11), (12), (16), (18) and (19)-- and ten endogenous, five exogenous, and four predetermined endogenous variables. It is a simultaneous equations system which can be written in the following form using matrix notation.

$$A + B(Y)_t + C(Y)_{t-1} + D(X)_t = 0. \qquad (21)$$

where

A= 10x10 matrix of constant terms,

B= 10x10 matrix of coefficients of dependent variables,

C= 10x10 matrix of coefficients of lagged dependent variables,

D= 10x5 matrix of coefficients of exogenous variables,

$Y_t$= 10x1 column vector of endogenous variables, and

$X_t$= 5x1 column vector of exogenous variables.

By treating predetermined lagged dependent variables as exogenous ones, the model is an <u>ordinary equations system</u>; by solving it, the <u>reduced form</u> of the model is obtained, that is,

$$Y_t = -B^{-1}A - B^{-1}C(Y)_{t-1} - B^{-1}D(X)_t \qquad (22)$$

In this equation, each of the endogenous variables is a function of all the exogenous variables included in the model--these are $\ln(GDP)_t$, $\ln(T_i)_{t-1}$ and $\tau_i$s. The ij$^{th}$ element of $[-B^{-1}D]$ measures the instantaneous impact of a unit change in the j$^{th}$ exogenous variable on the i$^{th}$ endogenous variable (impact multipliers).

For instance, the i$^{th}$ individual tax yield equation in its reduced form will be:

$$\ln(T_i)_t = \phi_{i0} + \phi_{i1}\ln(GDP)_t + \Sigma\phi_{ij2}\ln(T_j)_{t-1} + \Sigma\phi_{ij3}(\tau_j)_t \qquad (20)$$

where

$j$ =m, d, c, o,

$\phi_{i1}$ =short-run elasticity of the $T_i$ with respect to GDP,

$\phi_{ij3}$=percentage changes in $T_i$ due to a one percentage point change in $\tau_j$; for i#j, it measures the short-run impact of changes in the j$^{th}$ individual tax system on the i$^{th}$ individual tax revenue (cross-DTM indirect response), and, for $i=j$, it measures the short run overall impact of a one percentage point increase in $\tau_i$ on its corresponding tax yield (sum of the own-DTM direct and indirect responses). Its short run own-DTM direct response is measured by the coefficient of $\tau_i$ in equation (3), in other words, $\alpha_{i3}$; therefore, its short run own-DTM indirect response is simply measured by $\phi_{ii3}-\alpha_{i3}$.

The elements of $[-B^{-1}D]$ related to the coefficients of ln(GDP), measuring the short-run tax elasticities, and $\tau_j$s, measuring the short-run revenue impacts of DTMs, are presented in Tables 3-7.

By treating lagged dependent variables as endogenous ones, the structural form of the model is a <u>system of difference equations</u>; by solving it, the <u>final form</u> of the model is obtained which is,

$$Y_t = [I + B^{-1}C]^{-1}[-B^{-1}A] + [I + B^{-1}C]^{-1}[-B^{-1}D](X)_t \qquad (23)$$

where

I= 10x10 unit matrix.

In this equation, each of the endogenous variables is a function of all the exogenous variables included in the model--these are ln(GDP) and $\tau_j$s. The $ij^{th}$ element of $\{[I+B^{-1}C]^{-1}[-B^{-1}D]\}$ measures the total impact of a unit change in the $j^{th}$ exogenous variable on the $i^{th}$ endogenous variable (total multipliers). For instance, the $i^{th}$ individual tax yield equation in its final form will be:

$$\ln(T_i)_t = \psi_{i0} + \psi_{i1}\ln(GDP)_t + \Sigma\psi_{ij2}(\tau_j)_t \quad \text{for } j=m,d,c,o \qquad (21)$$

Table 3: Short Run and Long Run Individual and Overall Tax Elasticities in Terms of the Parameters Included in the Model

| Tax Yields | Tax Elasticities |
|---|---|
| A. Short Run: | |
| Total Tax (T) | $\delta_m\alpha_{m1}\beta_{m1}+\delta_d\alpha_{d1}\beta_{d1}(\gamma_1+\alpha_{c1}\beta_{c1}\gamma_2+\gamma_3\alpha_{o1})+\delta_c\alpha_{c1}\beta_{c1}+\delta_o\alpha_{o1}$ |
| -Import Tax ($T_m$) | $\alpha_{m1}\beta_{m1}$ |
| -Consumption Tax ($T_d$) | $\alpha_{d1}\beta_{d1}(\gamma_1+\alpha_{c1}\beta_{c1}\gamma_2+\gamma_3\alpha_{o1})$ |
| -Corporate Income Tax ($T_c$) | $\alpha_{c1}\beta_{c1}$ |
| -Other Direct Taxes ($T_o$) | $\alpha_{o1}$ |
| B. Long Run: | |
| Total Tax (T) | $\frac{\delta_m\alpha_{m1}\beta_{m1}}{1-\alpha_{m2}}+\frac{\delta_d\alpha_{d1}\beta_{d1}}{1-\alpha_{d2}}\times\left[\gamma_1+\frac{\alpha_{c1}\beta_{c1}\gamma_2}{1-\alpha_{c2}}+\frac{\gamma_3\alpha_{o1}}{1-\alpha_{o2}}\right]+\frac{\delta_c\alpha_{c1}\beta_{c1}}{1-\alpha_{c2}}+\frac{\delta_o\alpha_{o1}}{1-\alpha_{o2}}$ |
| -Import Tax ($T_m$) | $\frac{\alpha_{m1}\beta_{m1}}{1-\alpha_{m2}}$ |
| -Consumption Tax ($T_d$) | $\frac{\alpha_{d1}\beta_{d1}}{1-\alpha_{d2}}\times\left[\gamma_1+\frac{\alpha_{c1}\beta_{c1}\gamma_2}{1-\alpha_{c2}}+\frac{\gamma_3\alpha_{o1}}{1-\alpha_{o2}}\right]$ |
| -Corporate Income Tax ($T_c$) | $\frac{\alpha_{c1}\beta_{c1}}{1-\alpha_{c2}}$ |
| -Other Direct Taxes ($T_o$) | $\frac{\alpha_{o1}}{1-\alpha_{o2}}$ |

Table 4: Direct and Indirect Responses of Individual and Overall Tax Revenues to the Changes in the Domestic Consumption Tax System

| Type of Tax | Percentage Changes in Tax Yields due to $\Delta\tau_d$=1% |
|---|---|
| **A. Short Run Response:** | |
| Total Tax | |
| Direct Response | $\delta_d \alpha_{d3}$ |
| Indirect Response | $\delta_m \alpha_{m1} \beta_{m2} \theta_2 + \delta_d \alpha_{d1} \theta_2 (\beta_{d2} + \gamma_2 \beta_{d1} \alpha_{c1} \beta_{c3}) + \delta_c \alpha_{c1} \beta_{c3} \theta_2$ |
| -Import Tax | |
| Indirect Response | $\alpha_{m1} \beta_{m2} \theta_2$ |
| -Consumption Tax | |
| Direct Response | $\alpha_{d3}$ |
| Indirect Response | $\alpha_{d1} \theta_2 (\beta_{d2} + \gamma_2 \beta_{d1} \alpha_{c1} \beta_{c3})$ |
| -Corporate Income Tax | |
| Indirect Response | $\alpha_{c1} \beta_{c3} \theta_2$ |
| **B. Long Run Response:** | |
| Total Tax | |
| Direct Response | $\delta_d (\alpha_{d3})/(1 - \alpha_{d2})$ |
| Indirect Response | $\frac{\delta_d \alpha_{d1} \theta_2}{1 - \alpha_{d2}} \times \left[\beta_{d2} + \frac{\gamma_2 \beta_{d1} \alpha_{c1} \beta_{c3}}{1 - \alpha_{c2}}\right] + \frac{\delta_m \alpha_{m1} \beta_{m2} \theta_2}{1 - \alpha_{m2}} + \frac{\delta_c \alpha_{c1} \beta_{c3} \theta_2}{1 - \alpha_{c2}}$ |
| -Import Tax | |
| Indirect Response | $(\alpha_{m1} \beta_{m2} \theta_2)/(1 - \alpha_{m2})$ |
| -Consumption Tax | |
| Direct Response | $(\alpha_{d3})/(1 - \alpha_{d2})$ |
| Indirect Response | $\frac{\alpha_{d1} \theta_2}{1 - \alpha_{d2}} \times \left[\beta_{d2} + \frac{\gamma_2 \beta_{d1} \alpha_{c1} \beta_{c3}}{1 - \alpha_{c2}}\right]$ |
| -Corporate Income Tax | |
| Indirect Response | $(\alpha_{c1} \beta_{c3} \theta_2)/(1 - \alpha_{c2})$ |

Table 5: Direct and Indirect Responses of Individual and Overall Tax Revenues to Changes in the Import Tax System

| Type of Tax | Percentage Changes in Tax Yields due to $\Delta\tau_m$=1% |
|---|---|
| **A. Short Run Response:** | |
| Total Tax | |
| Direct Response | $\delta_m\alpha_{m3}$ |
| Indirect Response | $\delta_m\alpha_{m1}\beta_{m2}\theta_1 + \delta_d\alpha_{d1}\theta_1(\beta_{d2} + \beta_{d1}\gamma_2\alpha_{c1}\beta_{c3}) + \delta_c\alpha_{c1}\beta_{c3}\theta_1$ |
| -Import Tax | |
| Direct Response | $\alpha_{m3}$ |
| Indirect Response | $\alpha_{m1}\beta_{m2}\theta_1$ |
| -Consumption Tax | |
| Indirect Response | $\alpha_{d1}\theta_1(\beta_{d2} + \beta_{d1}\gamma_2\alpha_{c1}\beta_{c3})$ |
| -Corporate Income Tax | |
| Indirect Response | $\alpha_{c1}\beta_{c3}\theta_1$ |
| **B. Long Run Response:** | |
| Total Tax | |
| Direct Response | $\delta_m(\alpha_{m3})/(1 - \alpha_{m2})$ |
| Indirect Response | $\dfrac{\delta_d\alpha_{d1}\theta_1}{1-\alpha_{d2}} \times \left[\beta_{d2} + \dfrac{\alpha_{c1}\beta_{c3}\beta_{d1}\gamma_2}{1 - \alpha_{c2}}\right] + \dfrac{\delta_m\alpha_{m1}\beta_{m2}}{1 - \alpha_{m2}} + \dfrac{\delta_c\alpha_{c1}\beta_{c3}\theta_1}{1 - \alpha_{c2}}$ |
| -Import Tax | |
| Direct Response | $(\alpha_{m3})/(1 - \alpha_{m2})$ |
| Indirect Response | $(\alpha_{m1}\beta_{m2}\theta_1)/(1 - \alpha_{m2})$ |
| -Consumption Tax | |
| Indirect Response | $\dfrac{\alpha_{d1}\theta_1}{1-\alpha_{d2}} \times \left[\beta_{d2} + \dfrac{\alpha_{c1}\beta_{c3}\beta_{d1}\gamma_2}{1 - \alpha_{c2}}\right]$ |
| -Corporate Income Tax | |
| Indirect Response | $(\alpha_{c1}\beta_{c3}\theta_1)/(1 - \alpha_{c2})$ |

Table 6: Direct and Indirect Responses of Individual and Overall Tax Revenues to the Changes in the Corporate Income Tax System

| Type of Tax | Percentage Changes in Tax Yields due to $\Delta\tau_c$=1% |
|---|---|
| A. Short Run Response: | |
| Total Tax | |
| Direct Response | $\delta_c\alpha_{c3}$ |
| Indirect Response | $\delta_c\alpha_{c1}\beta_{c2} + \delta_d\alpha_{d1}\beta_{d1}\gamma_2(\alpha_{c1}\beta_{c2} + \alpha_{c3}) + \delta_m\alpha_{m1}\beta_{m3}$ |
| -Import Tax | |
| Indirect Response | $\alpha_{m1}\beta_{m3}$ |
| -Consumption Tax | |
| Indirect Response | $\alpha_{d1}\beta_{d1}\gamma_2(\alpha_{c1}\beta_{c2} + \alpha_{c3})$ |
| -Corporate Income Tax | |
| Direct Response | $\alpha_{c3}$ |
| Indirect Response | $\alpha_{c1}\beta_{c2}$ |
| B. Long Run Response: | |
| Total Tax | |
| Direct Response | $(\delta_c\alpha_{c3})/(1 - \alpha_{c2})$ |
| Indirect Response | $\dfrac{\delta_c\alpha_{c1}\beta_{c2}}{(1 - \alpha_{c2})} + \dfrac{\delta_d\alpha_{d1}\beta_{d1}\gamma_2(\alpha_{c1}\beta_{c2} + \alpha_{c3})}{(1 - \alpha_{c2})(1 - \alpha_{d2})} + \dfrac{\alpha_{m1}\beta_{m3}}{1-\alpha_{m2}}$ |
| -Import tax | |
| Indirect Response | $\alpha_{m1}\beta_{m3}/(1-\alpha_{m2})$ |
| -Consumption Tax | |
| Indirect Response | $\dfrac{\alpha_{d1}\beta_{d1}\gamma_2(\alpha_{c1}\beta_{c2} + \alpha_{c3})}{(1 - \alpha_{d2})(1 - \alpha_{c2})}$ |
| -Corporate Income Tax | |
| Direct Response | $(\alpha_{c3})/(1 - \alpha_{c2})$ |
| Indirect Response | $(\alpha_{c1}\beta_{c2})/(1 - \alpha_{c2})$ |

Table 7: Direct and Indirect Responses of Individual and Overall Tax Revenues to the Changes in Other Direct Tax Systems

| Type of Tax | Percentage Changes in Tax Yields due to $\Delta\tau_o$=1% |
|---|---|
| A. Short Run Response: | |
| Total Tax | |
| Direct Response | $\delta_o\alpha_{o3}$ |
| Indirect Response | $\delta_o\alpha_{d1}\beta_{d1}\gamma_3\alpha_{o3}$ |
| -Consumption Tax | |
| Indirect Response | $\alpha_{d1}\beta_{d1}\gamma_3\alpha_{o3}$ |
| -Other Direct taxes | |
| Direct Response | $\alpha_{o3}$ |
| B. Long Run Response: | |
| Total Tax | |
| Direct Response | $(\delta_o\alpha_{o3})/(1 - \alpha_{o2})$ |
| Indirect Response | $\dfrac{\delta_o\alpha_{d1}\beta_{d1}\gamma_3\alpha_{o3}}{(1 - \alpha_{o2})(1 - \alpha_{d2})}$ |
| -Consumption Tax | |
| Indirect Response | $\dfrac{\alpha_{d1}\beta_{d1}\gamma_3\alpha_{o3}}{(1 - \alpha_{d2})(1 - \alpha_{o2})}$ |
| -Other Direct Taxes | |
| Direct Response | $(\alpha_{o3})/(1 - \alpha_{o2})$ |

where

$\psi_{i1}$ =long-run elasticity of $T_i$ with respect to GDP, and

$\psi_{ij2}$=the long-run Response of $T_i$ to one percentage point change in $\tau_j$

The elements of $([I+B^{-1}C]^{-1}[-B^{-1}D])$ which are related to the coefficients of ln(GDP)--the long run individual and overall tax elasticities--and $\tau_j$s--the long run direct and indirect responses of tax revenues to DTMs-- are presented in Tables 3-7.

To summarize, all the existing estimation methods of tax elasticity suffer from a specification bias which is created in the process of dealing with the lack of an observable quantitative variable capable of reflecting all changes in an individual (or overall) tax system in public finance. The estimation technique developed in this chapter is a dynamic simultaneous-equation econometric model of taxation which deals with this lack and thus, with its consequences on the estimate of tax elasticity. That is: (i) as representative of each individual tax system, its "average effective tax rate net of endogenous changes in its tax yield and base" (AETRN) is introduced in the model on which time series data are automatically generated in the process of estimating the model parameters; (ii) this model incorporates <u>both</u> the direct and indirect responses of each individual tax yield to the changes in its own <u>as well as</u> other individual tax systems, i.e., own-DTM direct, own-DTM indirect and cross-DTM indirect responses; and (iii) its application requires <u>only</u> historical time series data on individual tax revenues and bases and gross domestic products, all of which are already available for most countries.

The parameters of the model are estimated by means of a simultaneous-equation econometric technique. Its impact and total multipliers (dynamic multipliers) are then derived by solving it respectively as an ordinary and a difference equations system. These multipliers measure the short run and long run (i) elasticities of individual tax yields, individual tax bases and overall tax revenue with respect to GDP, and (ii) responses of each individual tax yield and tax base to the changes in its own and other individual tax systems.

In addition to its application as a method for estimating tax elasticity and the revenue impact of DTMs, this model can be used as an empirical framework:

(1) to forecast a government's revenue from various sources of taxation;

(2) to evaluate the macroeconomic impact of a tax reform program which is aimed at either generating additional revenue and/or dealing with specific economic problems--this simply requires converting the DTMs included in that reform into $AETRN_i$s (for more details see Appendix C); and

(3) to deal with various tax related economic issues which may require further disaggregation of individual tax yields and bases--for example, to investigate the welfare impact of moving from differential tariffs towards uniform ones, which is often recommended by the Bank, or to examine the controversial view that uniform tariffs result in uniform rates of effective protection in industrial and non-industrial activities.

# CHAPTER III

# APPLICATION OF THE MODEL

The objective of this chapter is to highlight the contribution of discretionary tax measures to trends of tax shares and tax effort in two SSA countries during the past two decades. These are Malawi and Mautitius which have exhibited different trends in an important aspect of public finance, that is, a shift from the taxation of international trade to the taxation of domestic transactions which has taken place in Malawi while, in Mauritius, government's reliance on foreign trade taxes has risen. The model developed in the previous chapter is econometrically applied to the time series data of these countries in order to accomplish this aim.

In the first section, the estimation method and results are discussed, and the dynamic multipliers of the model are derived. Using the obtained results, the trends of tax shares and effort are analyzed in the second section.

## Estimation Method and Empirical Results

Time series data are used to estimate the parameters of the model. These data and their corresponding sources are supplied in the Appendix A.

Because of using time series data, there is the possibility of the presence of serial correlation. If this is ignored, the estimate of the parameters will be (a) inconsistent, which means that conducting any kind of test related to these parameters will be unreliable, and (b) biased, that is, parameters of such an equation will be overestimated (or underestimated) if the coefficient of the serial correlation is positive (or negative).[1] To test the hypothesis of zero autocorrelation in the tax base and tax yield equations, "DW" and "h" statistics are respectively used in this study.[2]

To estimate these two statistics, the parameters of the model were estimated by means of a non-linear two-stage least squares (N2SLS) method. All of the estimated parameters had the expected signs and plausible sizes except those of the lagged dependent variable in Malawi's domestic consumption tax yield function and those of other direct tax and domestic consumption tax equations of Mauritius, which had contrary signs and were insignificant. These variables were dropped from those equations and the model parameters re-estimated by means of N2SLS. Then, the estimation results were used to calculate the "h" and "DW" statistics which are presented in Table 8.

It is apparent from the information supplied in this Table that the hypothesis of zero serial correlation is not rejected at the 5 percent level in the domestic consumption tax yield and import tax base equations

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1/ See Maddala (1987), pp. 371-73.

2/ DW statistics are derived under the assumption that regressors are fixed (non-stochastic); hence, they are not applicable in cases where some of the regressors are lagged dependent variables, such as the tax revenue equations in the model developed in this study. In such cases, "h" statistics are applied whose estimate is derived as follows:

$$h=\rho[n/(1-n\sigma^2)]^{0.5}$$

where $\rho$=coefficient of serial correlation, n=number of observation and $\sigma$=sample standard deviation of coefficient of the lagged dependent variables. This statistic has standard normal distribution and the null hypothesis of zero autocorrelation is rejected at the 5 percent significance level if h > 1.64; for more details see Durbin (1970).

of Malawi. The test is inconclusive in the import and corporate income tax base functions of Mauritius.

The following procedure was used to deal with this econometric problem in these equations. Using the first-order autocorrelation scheme,

Table 8: Test Results for Serial Correlation

| Equations | Malawi | | Mauritius | |
|---|---|---|---|---|
| | DW | h | DW | h |
| Tax Revenue Block: | | | | |
| Import Tax | -- | 2.54 | -- | 2.07 |
| Consumption Tax | 0.512* | - | 1.86 | - |
| Corporate Income Tax | - | 1.70 | - | 2.72 |
| Other Direct Tax | - | 1.84 | 1.77 | - |
| Tax Base Block: | | | | |
| Import Tax | 0.940* | - | 1.16** | - |
| Consumption Tax | 1.65 | - | 1.98 | - |
| Corporate Income Tax | 1.54 | - | 3.04** | - |

* Hypothesis of no serial correlation is not rejected.
**The test is inconclusive.

the original equation was lagged one period. Both sides of this equation were then multiplied by the coefficient of serial correlation ($\rho$) whose estimate is unknown; its subtraction from the original equation produced a new equation in which disturbance terms were not correlated pairwisely. Finally, this new equation was replaced by the original one in the process of estimation.

After correcting for serial correlation, the efficient and consistent estimates of parameters of the model as a difference equations system were obtained by means of a non-linear 3SLS technique. The N3SLS estimation results--the structural form of the models with estimated parameters--for Malawi and Mauritius respectively are presented in Tables 9 and 10.

In order to test the goodness-of-fit of the entire estimated model a within-sample dynamic simulation was performed for all of the endogenous variables. A comparison of the actual and simulated values gives an indication of whether the model is able to capture the historical behavior of the endogenous variables. The simulated and actual values of the individual tax yields (logs) for Malawi and Mauritius respectively are shown in figures 2a-2d and 3a-3d. These charts indicate that these models are fairly accurate in capturing the historical movements of those variables. The coefficients of determination and mean-sum of squares of errors presented in Tables 9 and 10 support the goodness-of-fits observed in Figures 2a-2d and 3a-3d.

The estimated coefficients of all of the explanatory variables in these models have the expected signs and plausible sizes. All are significantly different from zero at more than 95 percent probability level except (a) those of $\tau_i$s in the corporate income tax base equation of Malawi--these being significantly different from zero at the 85 percent probability level--and (b) the adjustment coefficients of the $T_m$ and $T_o$ in this country--these being significantly equal to one.

Consequently, in both countries, discretionary tax measures have had a significant impact on both individual tax revenues and bases during the past two decades. This means that the market mechanism works fairly well in these countries and that tax policy has been an effective policy instrument

Table 9: Econometric Model of Taxation in Malawi
(N3SLS Estimation Results)

Equations included in the model*

**Stochastic Equations:**

| Equation | Statistics |
|---|---|
| $\ln(T_m)_t = -2.726 + 0.898\ln(X_m)_t + 0.019\ln(T_m)_{t-1} + 0.081(\tau_m)_t$ | $R^2=0.987$ |
| (-10.81) (14.41) (0.43) (12.23) | MSE=0.0025 |
| $\ln(T_d)_t = -3.623 + 0.905\ln(X_d)_t + 0.194(\tau_d)_t$ | $R^2=0.961$ |
| (-2.2) (3.11) (15.77) | MSE=0.0173 |
| $\ln(T_c)_t = -3.261 + 0.852\ln(X_c)_t + 0.129\ln(T_c)_{t-1} + 0.141(\tau_c)_t$ | $R^2=0.992$ |
| (-9.51) (10.96) (2.26) (8.44) | MSE=0.0022 |
| $\ln(T_o)_t = -4.485 + 0.960\ln(GDP)_t + 0.027\ln(T_o)_{t-1} + 0.380(\tau_{ot})_t$ | $R^2=0.998$ |
| (-32.1) (34.3) (1.35) (32.5) | MSE=0.0001 |
| $\ln(X_m)_t = +0.394 + 0.631\ln(GDP)_t - 0.030(\tau_m/\tau_d)_t + 0.073(\tau_c)_t$ | $R^2=0.966$ |
| (1.23) (5.41) (-1.88) (2.45) | MSE=0.0111 |
| $\ln(X_d)_t = -0.033 + 1.021\ln(Y_d)_t + 0.024(\tau_m/\tau_d)_t$ | $R^2=0.982$ |
| (-2.10) (42.7) (4.02) | MSE=0.0038 |
| $\ln(X_c)_t = -1.09 + 1.111\ln(GDP)_t - 0.014(\tau_c)_t + 0.0047(\tau_m/\tau_d)_t$ | $R^2=0.990$ |
| (-11.4) (65.4) (-1.67) (1.34) | MSE=0.0014 |

Identities:

$$\ln(T)_t = 1.41 + 0.286n(T_m)_t + 0.292\ln(T_d)_t + 0.242\ln(T_c)_t + 0.180\ln(T_o)_t$$

$$\ln(Y_d)_t = -0.29 + 1.066\ln(GDP)_t - 0.038\ln(T_{co})_t - 0.027\ln(T_o)_t$$

$$(\tau_m/\tau_d)_t = 1.845 + 0.08(\tau_m)_t - 0.271(\tau_d)_t$$

* Within parentheses are "t" statistics; MSE=mean squares errors; $\tau_i$s are in percentage form.

Table 10: Econometric Model of Taxation in Mauritius
(N3SLS Estimation Results)

Equations included in the model*

**Stochastic Equations:**

$\ln(T_m)_t = -1.643 + 0.683\ln(X_m)_t + 0.231\ln(T_m)_{t-1} + 0.048(\tau_m)_t$ $R^2=0.998$
(-6.30) (10.41) (4.22) (8.53) MSE=0.0001

$\ln(T_d)_t = -3.817 + 0.998\ln(X_d)_t + 0.169(\tau_d)_t$ $R^2=0.999$
(-236.4) (429.5) (83.7) MSE=0.00004

$\ln(T_c)_t = -3.686 + 0.828\ln(X_c)_t + 0.095\ln(T_c)_{t-1} + 0.330(\tau_c)_t$ $R^2=0.992$
(-7.91) (10.1) (1.44) (8.31) MSE=0.0089

$\ln(T_o)_t = -3.965 + 0.972\ln(GDP)_t + 0.223(\tau_{ot})_t$ $R^2=0.997$
(-31.6) (69.7) (23.9) MSE=0.0022

$\ln(X_m)_t = -1.844 + 1.157\ln(GDP)_t - 0.091(\tau_m/\tau_d)_t + 0.047(\tau_c)_t$ $R^2=0.994$
(-1.12) (50.9) (-2.30) (3.44) MSE=0.0066

$\ln(X_d)_t = 2.296 + 0.763\ln(Y_d)_t + 0.088(\tau_m/\tau_d)_t$ $R^2=0.996$
(1.19) (8.62) (2.51) MSE=0.0041

$\ln(X_c)_t = -0.258 + 0.993\ln(GDP)_t - 0.020(\tau_c)_t + 0.095(\tau_m/\tau_d)_t$ $R^2=0.999$
(-2.85) (83.2) (-3.41) (6.43) MSE=0.0009

Identities:

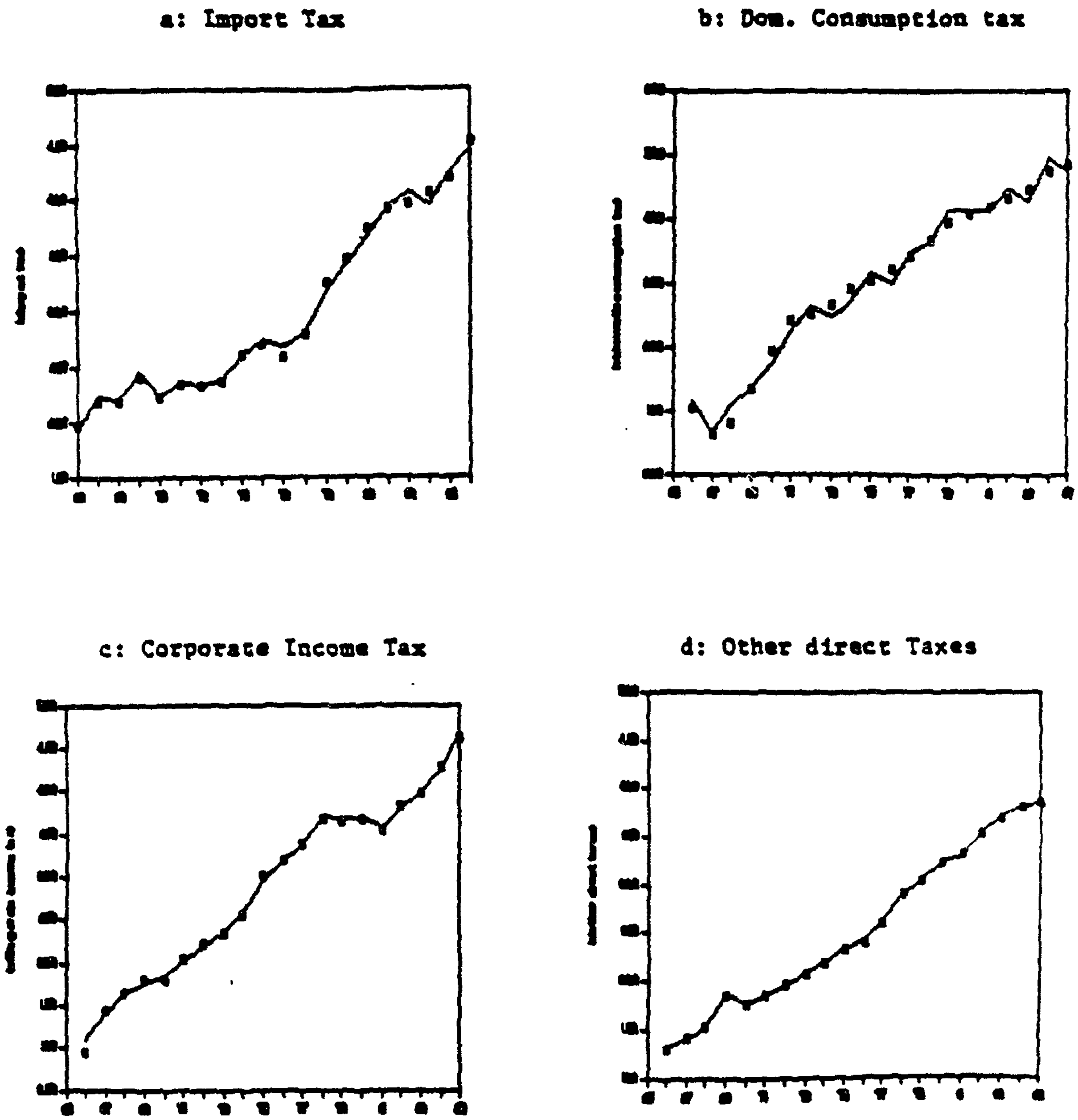
$$\ln(T)_t = 1.25 + 0.504\ln(T_m)_t + 0.155\ln(T_d)_t + 0.099\ln(T_c)_t + 0.245\ln(T_o)_t$$

$$\ln(Y_d)_t = -0.258 + 1.056\ln(GDP)_t - 0.020\ln(T_c)_t - 0.036\ln(T_o)_t$$

$$(\tau_m/\tau_d)_t = 2.99 + 0.06(\tau_m)_t - 0.54(\tau_d)_t$$

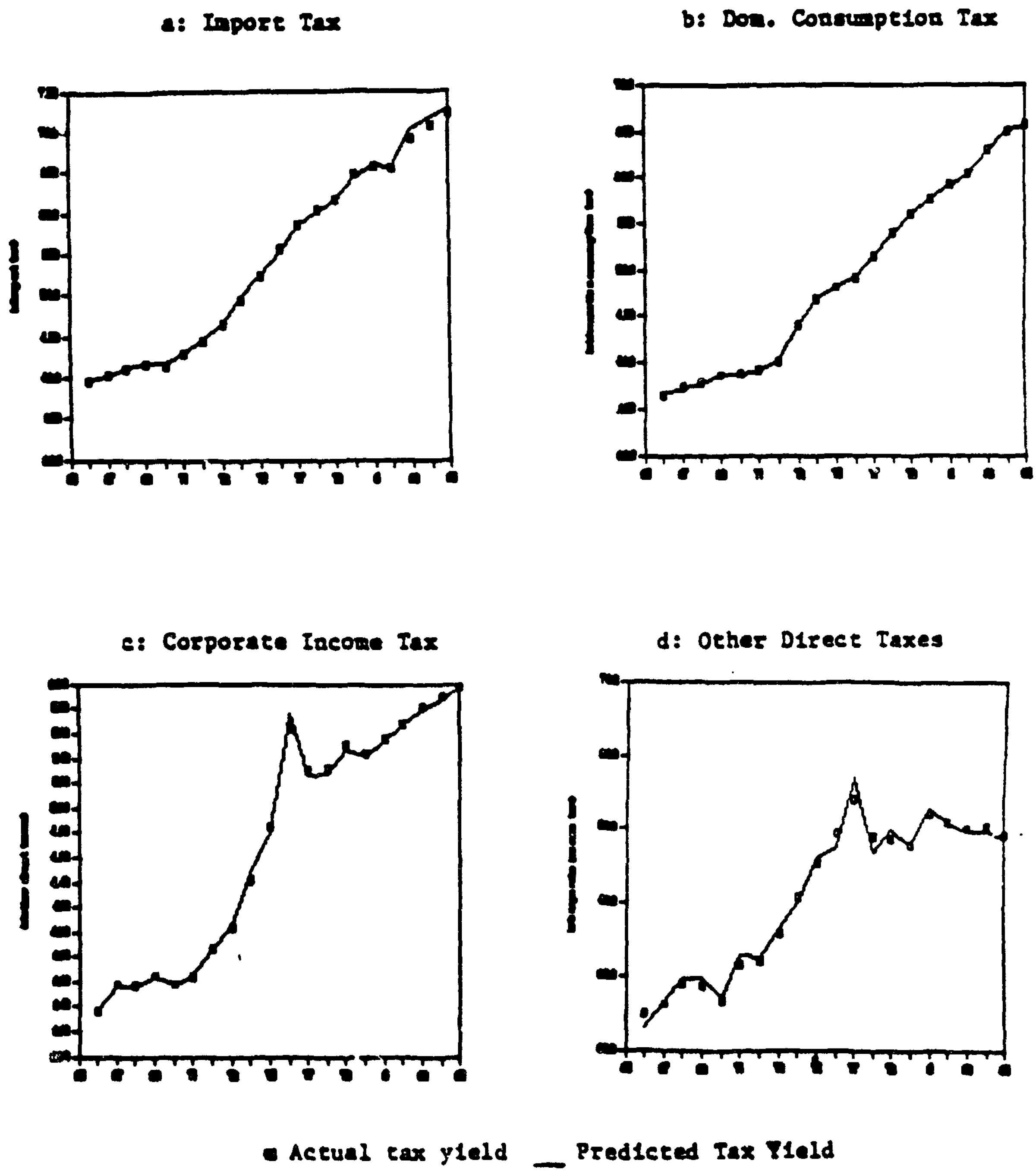
* Within parentheses are "t" statistics; MSE=mean squares errors; $\tau_i$s are in percentage form.

Figures 2a-2d: Actual and Predicted Values of Individual Tax Yields in Malawi (1965-85)




• Actual tax yield __ Predicted tax yield

Figures 3a-3d: Actual and Predicted Values of Individual Tax Yields in Mauritius (1965-85)



in mobilizing resources from the private sector to the public sector. This result strongly rejects the view that mobilizing resources through the tax system has been difficult in SSA countries (see Shalizi and Squire).

Tables 9 and 10 respectively presented the structural form of the models with estimated parameters for Malawi and Mauritius. Using the method explained in Chapter II, each of these models was solved as ordinary and difference equations systems in order to estimate the short run and long run impacts of changes in exogenous variables, ln(GDP) and $\tau_i$s, on endogenous ones, individual tax yields and bases and total tax revenue. The obtained results for Malawi and Mauritius are respectively presented in Tables 11 and 12 --where built-in elasticity of tax yields and bases with respect to GDP are supplied in column (a) and columns (b)-(e) represent the responses of each of the tax yields and bases to the changes in each of the individual tax systems ($\Delta\tau_i$=1) included in the model.

It is revealed from column (a) that the total and individual tax revenues are inelastic with respect to GDP except for import tax yield in Mauritius and corporate income tax revenue in Malawi whose long run elasticities exceed one. These exceptions emerge from the fact that imports in Mauritius and value added in the non-agriculture sector in Malawi grow faster than GDP. In other words, these two individual taxes are still inelastic with respect to their corresponding economic tax bases (0.78 and 0.91 respectively).

The data presented in columns (b) and (c) indicate that the overall response of the total tax revenue to a one percentage point increase in $\tau_m$ is larger than its direct response in both countries. This is due to the fact that a rise in $\tau_m$ reduces imports but raises private consumption and

Table 11: Short Run and Long Run Impact of Changes in Individual Tax Systems and GDP on Tax Revenues and Bases in Malawi*

| Tax Revenues and Bases | $\Delta\ln(GDP)=1\%$ (a) | $\Delta\tau_m=1$ (b) | $\Delta\tau_d=1$ (c) | $\Delta\tau_c=1$ (d) | $\Delta\tau_o=1$ (e) |
|---|---|---|---|---|---|
| **A. Short Run Impacts:** | | | | | |
| $\Delta\ln(T)$ | 0.8336 | 0.0229 | 0.0567 | 0.0486 | 0.0657 |
| | | (0.0232) | (0.0566) | (0.0341) | (0.0684) |
| $\Delta\ln(T_m)$ | 0.5666 | 0.0788 | 0.0073 | 0.0656 | 0.0000 |
| | | (0.0810) | | | |
| $\Delta\ln(T_d)$ | 0.9295 | 0.0017 | 0.1881 | -0.0042 | -0.0091 |
| | | | (0.1940) | | |
| $\Delta\ln(T_c)$ | 0.9466 | 0.0003 | -0.0011 | 0.1291 | 0.0000 |
| | | | | (0.1410) | |
| $\Delta\ln(T_o)$ | 0.9600 | 0.0000 | 0.0000 | 0.0000 | 0.3800 |
| | | | | | (0.3800) |
| $\Delta\ln(X_m)$ | 0.6310 | -0.0024 | 0.0081 | 0.0730 | 0.0000 |
| $\Delta\ln(X_d)$ | 1.0270 | 0.0019 | -0.0065 | -0.0046 | -0.0101 |
| $\Delta\ln(X_c)$ | 1.1110 | 0.0004 | -0.0013 | -0.0140 | 0.0000 |
| **B. Long Run Impacts:** | | | | | |
| $\Delta\ln(T)$ | 0.8740 | 0.0233 | 0.0567 | 0.0534 | 0.0676 |
| | | (0.0236) | (0.0567) | (0.0392) | (0.0703) |
| $\Delta\ln(T_m)$ | 0.5776 | 0.0804 | 0.0074 | 0.0668 | 0.0000 |
| | | (0.0826) | | | |
| $\Delta\ln(T_d)$ | 0.9243 | 0.0017 | 0.1882 | -0.0048 | -0.0094 |
| | | | (0.1940) | | |
| $\Delta\ln(T_c)$ | 1.0868 | 0.0004 | -0.0012 | 0.1482 | 0.0000 |
| | | | | (0.1619) | |
| $\Delta\ln(T_o)$ | 0.9866 | 0.0000 | 0.0000 | 0.0000 | 0.3905 |
| | | | | | (0.3905) |
| $\Delta\ln(X_m)$ | 0.6310 | -0.0024 | 0.0081 | 0.0730 | 0.0000 |
| $\Delta\ln(X_d)$ | 1.0213 | 0.0019 | -0.0065 | -0.0053 | -0.0104 |
| $\Delta\ln(X_c)$ | 1.1110 | 0.0004 | -0.0013 | -0.0140 | 0.0000 |

* Within the parentheses is the direct response of tax revenue to the DTMs.

Table 12: Short Run and Long Run Impacts of Changes in Individual Tax Systems and GDP on Tax Yields and Bases in Mauritius*

| Tax Revenues and Bases | $\Delta\ln(GDP)=1\%$ (a) | $\Delta\tau_m=1$ (b) | $\Delta\tau_d=1$ (c) | $\Delta\tau_c=1$ (d) | $\Delta\tau_o=1$ (e) |
|---|---|---|---|---|---|
| **A. Short Run Impacts:** | | | | | |
| $\Delta\ln(T)$ | 0.8364 | 0.0237 | 0.0317 | 0.0465 | 0.0537 |
| | | (0.0328) | (0.0262) | (0.0327) | (0.0546) |
| $\Delta\ln(T_m)$ | 0.7902 | 0.0445 | 0.0336 | 0.0321 | 0.0000 |
| | | (0.0650) | | | |
| $\Delta\ln(T_d)$ | 0.7649 | 0.0052 | 0.1221 | -0.0048 | -0.0061 |
| | | | (0.169) | | |
| $\Delta\ln(T_c)$ | 0.8222 | 0.0047 | -0.0426 | 0.3134 | 0.0000 |
| | | | | (0.3300) | |
| $\Delta\ln(T_o)$ | 0.9720 | 0.0000 | 0.0000 | 0.0000 | 0.2230 |
| | | | | | (0.2230) |
| $\Delta\ln(X_m)$ | 1.1570 | -0.0055 | 0.0492 | 0.0470 | 0.0000 |
| $\Delta\ln(X_d)$ | 0.7665 | 0.0052 | -0.0470 | -0.0048 | -0.0061 |
| $\Delta\ln(X_c)$ | 0.9930 | 0.0057 | -0.0514 | -0.2000 | 0.0000 |
| **B. Long Run Impacts:** | | | | | |
| $\Delta\ln(T)$ | 0.9644 | 0.0305 | 0.0363 | 0.0545 | 0.0537 |
| | | (0.0426) | (0.0262) | (0.0361) | (0.0546) |
| $\Delta\ln(T_m)$ | 1.0276 | 0.0578 | 0.0437 | 0.0417 | 0.0000 |
| | | (0.0845) | | | |
| $\Delta\ln(T_d)$ | 0.7636 | 0.0052 | 0.1222 | -0.0053 | -0.0061 |
| | | | (0.1690) | | |
| $\Delta\ln(T_c)$ | 0.9085 | 0.0052 | -0.0470 | 0.3463 | 0.0000 |
| | | | | (0.3650) | |
| $\Delta\ln(T_o)$ | 0.9720 | 0.0000 | 0.0000 | 0.0000 | 0.2230 |
| | | | | | (0.2230) |
| $\Delta\ln(X_m)$ | 1.1570 | -0.0055 | 0.0492 | 0.0470 | 0.0000 |
| $\Delta\ln(X_d)$ | 0.7652 | 0.0052 | -0.0469 | -0.0053 | -0.0061 |
| $\Delta\ln(X_c)$ | 0.9930 | 0.0057 | -0.0514 | -0.0200 | 0.0000 |

* Within the parentheses is the direct response of tax revenue to the DTMs.

hence, value-added in the non-agriculture sector. As a result, import tax declines and domestic consumption and corporate income taxes rise, causing a net indirect increase in total tax revenue. This process is reversed when $\tau_d$ rises, that is, the overall response of the total tax revenue to a one percentage point rise in $\tau_d$ falls short of its direct response in both countries.

As far as changes in corporate income and other direct taxes are concerned, an increase in $\tau_c$ indirectly raises import tax and reduces domestic consumption and corporate income tax yields, resulting in a decline in the direct response of the total tax yield to $\tau_c$. This process is reversed when $\tau_o$ rises.

It is worth mentioning that, in Malawi, the elasticity of the domestic consumption tax revenue with respect to GDP is higher than that of the import tax yield while, in Mauritius, the former falls short of the latter. Furthermore, in Malawi, the direct revenue impact of changes in the domestic consumption tax system is much higher than that of the same changes in the import tax system while, in Mauritius, the former is smaller than the latter. These differences will obviously require a different reform combination of discretionary tax measures if such a reform is aimed at shifting from the taxation of international trade to the taxation of domestic transactions in these countries.

## Trends of Tax shares and Tax Effort

During the 1965-1985 period, the tax effort (total tax revenue over GDP) has grown by an annual average rate of 4.6 percent in Malawi and 1.4

percent in Mauritius. The share of domestic consumption in total tax revenue in Malawi has increased by an average annual rate of 2.56 percent and that of import tax yield has declined by 1.72 percent. In Mauritius, the trends of these shares have been reversed, recording average annual percentage changes of -0.62 and +1.83 respectively. As a result, the ratio of domestic consumption tax over import tax, measuring the size and direction of shift from the taxation of imports to the taxation of domestic transactions has changed by +4.3 and -2.4 percent per annum in these countries respectively.[3]

The time series data generated on $\tau_i$s reveal that fiscal authorities have taken a variety of discretionary tax measures in both countries during the same period, to the extent that $\tau_m$, $\tau_d$, $\tau_c$ and $\tau_o$ have increased respectively by average annual percentage points of 0.49, 0.44, 0.91 and 0.03 in Malawi and 0.45, 0.10, -0.02 and zero in Mauritius. Furthermore, nominal GDP has grown by an average annual rate of 12 percent in Malawi and 14 percent in Mauritius.[4]

It is important to isolate the contribution of DTMs from that of economic growth to the trends of tax effort and tax shares in these countries, as it makes it possible to explore the role that DTMs have played in effecting the shift from the taxation of imports to the taxation of domestic transactions in Malawi, and to question the effectiveness of DTMs as a policy instrument for bringing about such a shift in Mauritius. To accomplish this aim, first, the built-in elasticity of each of these trends with respect to GDP is derived using the individual and overall tax

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3/ Tables 2-7 in Appendix A.

4/ Tables 2-7 in Appendix A.

elasticities estimated in the previous section. Then, their buoyancies are estimated using the estimate of the individual and overall tax buoyancies presented in Table 13, and finally, the contribution of DTMs to each of these trends is calculated by subtracting the elasticity of that trend from its buoyancy.

The built-in elasticity of each of these trends is the difference between the built-in elasticities of the variables appearing in its numerator and denominator, that is,

$$[\Delta\ln(T_i/T)]/[\Delta\ln(GDP)] = \mu_i - \mu \qquad (i)$$

$$[\Delta\ln(T/GDP)]/[\Delta\ln(GDP)] = \mu - 1 \qquad (ii)$$

$$[\Delta\ln(T_d/T_m)]/[\Delta\ln(GDP)] = \mu_d - \mu_m \qquad (iii)$$

where

i= d, domestic consumption tax,

= m, import tax,

= c, corporate income tax,

= o, other direct taxes,

$\mu_i$= built-in elasticity of the $i^{th}$ individual tax yield, and

$\mu$ = built-in elasticity of overall tax revenue.

Using the estimates of $\mu$ and $\mu_i$s presented in Table 13, the built-in elasticities of these trends--measuring their automatic response to variations in GDP--were estimated by means of equations (i), (ii) and (iii). The results are presented in Table 14.

Similarly, the buoyancy of each of them is the difference between the buoyancies of the variables appearing in its numerator and denominator, that is,

$$[\Delta\ln(T_i/T)^*]/[\Delta\ln(GDP)] = \xi_i - \xi \qquad (i)'$$

$$[\Delta\ln(T/GDP)^*]/[\Delta\ln(GDP)] = \xi - 1 \qquad (ii)'$$

$$[\Delta\ln(T_d/T_m)^*]/[\Delta\ln(GDP)] = \xi_d - \xi_m \qquad (iii)'$$

where

$\xi$ = buoyancy of overall tax revenue, and

$\xi_i$= buoyancy of the $i^{th}$ individual tax yield.

Using estimates of $\xi$ and $\xi_i$s presented in Table 13, the buoyancy of these trends--measuring their total response, including the impact of DTMs, to variations in GDP--were estimated by means of equations (i)', (ii)' and (iii)'. The results are presented in Table 14.

Table 13: Individual and Overall Tax Elasticities and Buoyancies in Malawi and Mauritius

| | Malawi | | Mauritius | |
|---|---|---|---|---|
| | Buoyancy[1] | Elasticity[2] | Buoyancy[1] | Elasticity[2] |
| Total Tax | 1.31 | 0.88 | 1.09 | 0.97 |
| Import Tax | 1.06 | 0.58 | 1.19 | 1.03 |
| Consumption Tax | 1.72 | 0.92 | 1.05 | 0.76 |
| Corporate Income Tax | 1.43 | 1.09 | 0.97 | 0.91 |
| Other Direct Taxes | 1.09 | 0.99 | 0.95 | 0.97 |

1/ Tax Buoyancies were obtained by estimating the parameters of the following econometric model.

$$\ln(T_i)_t = \omega_0 + \omega_i \ln(GDP)_t + U_t$$

where $\omega_i$ is buoyancy.

2/ From Tables 11 and 12.

Finally, by subtracting the elasticity of each of these trends from its buoyancy, the contribution of DTMs to that trend was estimated in terms of variations in GDP. The results are presented in Table 14.

It is revealed from this Table that the growth of tax effort has been mainly due to discretionary tax measures, to the extent that tax effort would fall in the absence of these measures during the period under review. This result is in strong opposition to the view that mobilizing resources from the private sector to the public sector through the tax system has been difficult in SSA countries.

In Malawi, 88 percent of the overall growth rate of domestic consumption tax share has emerged from discretionary tax measures while, in Mauritius, economic growth has dominated the trend of this tax share, contributing 500 percent to its overall negative growth rate.

Economic growth has been the principal contributor to the downward trend of import tax share in Malawi. Its contribution accounts for 116 percent of the overall average annual percentage decline in this tax share. In Mauritius, both discretionary tax measures and economic growth have significantly contributed to the overall growth rate of import tax share, out of which 40 percent has emerged from the former factor and 60 percent has come from the latter one.

It is apparent from the information presented in Table 14 that the contribution of discretionary tax measures to the trend of domestic tax share has been higher than its contribution to the trend of import tax share in both countries. This simply means that both countries would shift from the taxation of international trade to the taxation of domestic transactions in the absence of any change in GDP. However, due to

Table 14: Contribution of Discretionary Tax Measures and Economic Growth to Trends of Tax Shares and Effort in Malawi & Mauritius (percentage changes)

| | Buoyancy | Built-in Elasticity | Contribution of Discretionary Tax Measures |
|---|---|---|---|
| **Malawi:** | | | |
| Tax Effort | +0.31 | -0.12 | +0.43 |
| Import Tax Share | -0.25 | -0.29 | +0.04 |
| Domestic Consumption Tax Share | +0.41 | +0.05 | +0.36 |
| Corporate Income Tax Share | +0.10 | +0.21 | -0.11 |
| Other Direct Tax Share | -0.21 | +0.11 | -0.33 |
| Domestic Consumption Tax over Import Tax | +0.66 | +0.34 | +0.32 |
| **Mauritius:** | | | |
| Tax Effort | +0.09 | -0.03 | +0.11 |
| Import Tax Share | +0.10 | +0.06 | +0.04 |
| Domestic Consumption Tax Share | -0.04 | -0.20 | +0.16 |
| Corporate Income Tax Share | -0.12 | -0.06 | -0.06 |
| Other Direct Taxes Share | -0.14 | +0.01 | -0.15 |
| Domestic Consumption Tax over Import Tax | -0.14 | -0.26 | +0.12 |

structural differences mentioned in the previous section, this shift has been accelerated in Malawi and has been reversed in Mauritius. In Malawi, economic growth and discretionary tax measures have played almost equal roles in shifting from the taxation of international trade to the taxation of domestic transactions; they have contributed 51 and 49 percent respectively to the overall growth in domestic consumption tax-import tax ratio. In Mauritius, economic growth has dominated the downward trend of this ratio, indicating that this trend can be reversed only by means of an appropriate combination of discretionary tax measures.

# CHAPTER IV

# CONCLUSION

The structural adjustment programs of developing countries use fiscal deficit reduction as one of the policy tools for achieving real economic growth with price stability and balance of payments viability. In dealing with this deficit within such a framework, projections need to be made of the additional revenues which can be mobilized within the existing tax system as GDP grows. These projections indicate the need to activate additional means of revenue generation, particularly politically difficult discretionary tax measures. Thus, it becomes essential to be able to estimate built-in tax elasticity which measures percentage increases in tax revenue resulting from the endogenous changes in the base caused by a one percent rise in GDP. However, its estimation by means of any of the existing methods suffers from a specification bias due to lack of an obervable quantitative variable capable of reflecting all changes in an individual (or overall) tax system in public finance.

The central theme of this study has been twofold: first, to develop an econometric method of estimating tax elasticity and the revenue impact of DTMs which deals with this lack and, thus, with its consequences on the estimate of tax elasticity; and second, to use this model as an empirical framework to highlight the contribution of DTMs to trends of tax effort and tax shares in selected SSA countries during the past two decades.

The method to be developed in this research is a dynamic simultaneous-equation macroeconometric model of taxation which captures the interaction of individual tax systems, individual tax revenues and bases and GDP. As representative of each individual tax system, its "average effective tax rate net of endogenous (built-in) changes in the tax yield and base" (AETRN) is introduced into the model. Time series data on AETRNs are automatically generated in the process of estimating the model parameters. This model explicitly incorporates both the direct and indirect responses of each individual tax revenue to changes in its own and other individual tax systems, i.e., own-DTM direct, own-DTM indirect and cross-DTM indirect responses. Its application requires only historical time series data on tax revenues, tax bases and GDP, all of which are already available for most countries.

In addition to its application as a method for estimating tax elasticity and the revenue impact of DTMs, this model can be used as an empirical framework:

(a) to forecast a government's revenue from various sources of taxation;

(b) to evaluate the macroeconomic impact of a tax reform program which is aimed at either generating additional revenue and/or dealing with specific economic problems; and

(c) to deal with various tax related economic issues--for example, to investigate the welfare impact of moving from differential tariffs towards uniform ones, which is often recommended by the Bank, or to examine the controversial view that uniform tariffs result in uniform rates of effective protection in industrial and non-industrial activities.

A shift from the taxation of international trade to the taxation of domestic transactions is recommended, by both the Bank and the Fund, as one of the main objectives of a tax reform program in most developing countries. Such a reform is often included in structural adjustment programs. The presumption is that discretionary tax measures play a crucial role in effecting this shift. However, there is evidence indicating that this shift is also affected by endogenous changes in tax bases caused by factors other than these measures, particularly economic growth. The model developed in this study has been used as an empirical tool in order (i) to highlight the contribution that discretionary tax measures have made to the shift from the taxation of international trade to the taxation of domestic transactions in the countries, such as Malawi, where such a shift has taken place, and (ii) to question the effectiveness of these measures as a policy instrument for bringing about such a shift in other countries, such as Mauritius, where the country's reliance on the foreign trade tax has risen during the past two decades.

The econometric application of the model to the time series data of these countries yields a number of interesting results, for example:

(a) Discretionary tax measures have been an effective policy instrument for mobilizing resources from the private sector to the public sector in both countries, to the extent that tax effort would decline in the absence of DTMs. This result is strongly opposed to the view that mobilizing resources through the tax system has been difficult in SSA countries.

(b) Individual and overall tax revenues have been inelastic with respect to GDP in both countries except corporate income tax in Malawi and import tax in Mauritius whose long run built-in elasticities exceed one. These exceptions emerge from the fact that imports in Mauritius and value added in non-agriculture sector in Malawi have grown faster than GDP; in other words, these two individual taxes are still inelastic with respect to their corresponding tax base.

(c) The built-in elasticity of domestic consumption tax has exceeded that of import tax in Malawi while, in Mauritius, the former has fallen short of the latter. Therefore, economic growth has contributed to the shift from the taxation of imports to the taxation of domestic transactions in Malawi and has had a negative impact on this shift in Mauritius.

(d) The contribution of discretionary tax measures to the trend of domestic consumption tax share has been higher than its contribution to the trend of import tax share in both countries. This simply means that both countries would shift from the taxation of imports to the taxation of domestic transactions in the absence of economic growth. However, due to the structural differences mentioned above, economic growth accelerated such a shift in Malawi and reversed it in Mauritius.

(e) Finally, economic growth and discretionary tax measures have had almost equal roles in the shift from the taxation of international trade to the taxation of domestic transactions in Malawi,contributing 51 and 49 percent to the overall growth rate of domestic consumption tax-import tax ratio respectively. In Mauritius, economic growth has been the principal factor in reversing this shift, to the extent that this country would shift from the taxation of international trade to the taxation of domestic transactions in the absence of nominal economic growth.

The low degree of automatic responsiveness of tax yields to variations in GDP (tax elasticity) in these countries raises the following interesting question, which demands further research:

> **"Is there any way to improve the elasticity of these inelastic tax systems and, hence, gradually to reduce the need to take politically difficult discretionary tax measures?"**

This is a major gap remaining in the design of a tax reform.[5] It is an empirical matter which demands country-specific and/or cross-country analysis of trends of individual and overall tax elasticities. The model developed in this study can be used as an empirical tool to conduct such research.

Furthermore, it has been recognized, both by the Bank and the Fund, that most LDCs are in need of tax reform. A proper design of such reform, however, requires quantitative information on the impact of changes in each individual tax system not only on its corresponding tax revenue and base but also on the other individual tax yields and bases. Providing such information has been a complicated issue due to the lack of a satisfactory empirical framework. The model developed in this research is capable of producing this information. However, the generated information is at a highly aggregated level. That is, it provides estimates of impact of overall changes in each individual tax system on its corresponding and other individual tax bases and revenues, but it is not directly capable of disaggregating these impacts in terms of the various sources of changes in that individual tax system, such as changes in the statutory tax rate, tax

5/ See Shome (1987).

base, tax credits, tax allowances and tax administrative efficiency. Providing such disaggregated information demands further effort.

## APPENDIX A: HISTORICAL TIME SERIES DATA

Table 1: Trends of Tax Shares, Tax Bases and Tax Effort in Sub-Saharan Africa Countries

Table 2: Individual and Overall Tax Revenues in Malawi

Table 3: Individual and Total Tax Bases in Malawi

Table 4: Individual and Total Tax Revenues in Mauritius

Table 5: Individual and Total Tax Bases in Mauritius

Table 6: Generated Time Series on $\tau_i$s in Malawi

Table 7: Generated Time Series on $\tau_i$s in Mauritius

Table 1: Trends of Tax Shares, Tax Bases and Tax Effort in Sub-Saharan Africa Countries
(annual average percentage point changes)

| | Trends |
|---|---|
| A. Tax Effort | +0.40 |
| B. Tax Shares | |
| -Corporate Income Tax | +0.32 |
| -Domestic Consumption Tax | +0.15 |
| -Import Tax | -0.62 |
| C. Tax Bases | |
| -Corporate Income Tax | |
| Vn/GDP | +0.31 |
| (Vi/GDP) | (+0.40) |
| -Domestic Consumption Tax | |
| Cp/GDP | +0.30 |
| [(Cp+G)/GDP] | [+0.31] |
| [(Cp+G-Mc)/GDP] | [+0.09] |
| -Import Tax | |
| M/GDP | -0.20 |
| (Mc/GDP) | (-0.24) |

* Vi=value added in industry sector, Vn=value added in non-agriculture sector, Cp=private consumption, G=government consumption, Mc=consumption goods import, M=total imports, and GDP=gross domestic products.

Sources: For A Ehdaie, Gandhi and Shalizi and for B <u>World Development Report</u> 1987, pp. 16, 172, 212.

Table 2 : Individual and Overall Tax Revenues in Malawi
(000'000)

| Year | Total Tax | Import Tax | Export Tax | Tax on Domestic transactions | Corporate Income Tax | Other Direct Taxes |
|---|---|---|---|---|---|---|
| 1965 | 11.8 | 4.2 | 0.0 | 2.4 | 1.8 | 3.4 |
| 1966 | 16.2 | 7.1 | 0.0 | 2.8 | 2.6 | 3.7 |
| 1967 | 19.1 | 8.9 | 0.0 | 1.9 | 4.2 | 4.1 |
| 1968 | 20.9 | 8.9 | 0.0 | 2.2 | 5.2 | 4.6 |
| 1969 | 27.5 | 11.1 | 0.0 | 3.9 | 6.1 | 6.4 |
| 1970 | 28.2 | 9.3 | 0.0 | 7.0 | 6.1 | 5.8 |
| 1971 | 36.1 | 10.6 | 0.0 | 11.4 | 7.7 | 6.5 |
| 1972 | 39.3 | 10.3 | 0.0 | 12.7 | 9.1 | 7.1 |
| 1973 | 43.6 | 10.6 | 0.0 | 14.3 | 10.5 | 8.1 |
| 1974 | 53.8 | 13.6 | 0.0 | 18.5 | 12.8 | 9.0 |
| 1975 | 66.6 | 14.9 | 0.0 | 21.1 | 20.3 | 10.3 |
| 1976 | 73.2 | 13.3 | 0.0 | 24.6 | 24.2 | 11.1 |
| 1977 | 89.9 | 16.3 | 0.0 | 30.4 | 29.5 | 13.7 |
| 1978 | 121.9 | 25.8 | 0.0 | 38.8 | 38.9 | 18.4 |
| 1979 | 143.9 | 32.7 | 0.0 | 51.8 | 38.1 | 21.3 |
| 1980 | 166.9 | 42.1 | 0.0 | 59.8 | 39.5 | 25.6 |
| 1981 | 178.9 | 50.2 | 0.0 | 66.7 | 34.1 | 27.9 |
| 1982 | 207.7 | 52.5 | 0.0 | 75.6 | 45.2 | 34.4 |
| 1983 | 240.0 | 58.5 | 0.0 | 87.5 | 53.3 | 40.7 |
| 1984 | 296.3 | 66.6 | 0.0 | 112.3 | 72.2 | 45.2 |
| 1985 | 367.1 | 92.6 | 0.0 | 124.7 | 102.3 | 47.5 |

Sources: NA data file of Bank Economic and Social Data Base; GFS data file of IMF; Country Economic Memorandums, World Bank; and Recent Economic Development Report, IMF.

Table 3 : Individual and Total Tax Bases in Malawi
(000'000)

| Year | $GDP_{mp}$ | Import | Private Consumption | Export | Value Added in Non-Ag. |
|---|---|---|---|---|---|
| 1965 | 157.3 | 54.5 | 137.7 | 85.3 | 31.9 |
| 1966 | 176.1 | 69.4 | 152.5 | 100.6 | 40.0 |
| 1967 | 184.6 | 68.2 | 156.9 | 109.4 | 47.0 |
| 1968 | 193.2 | 80.0 | 167.2 | 117.7 | 48.7 |
| 1969 | 206.5 | 87.7 | 179.9 | 129.1 | 52.0 |
| 1970 | 225.8 | 94.8 | 176.3 | 142.9 | 58.7 |
| 1971 | 281.7 | 107.7 | 236.9 | 178.5 | 71.2 |
| 1972 | 302.5 | 123.5 | 248.6 | 187.1 | 75.8 |
| 1973 | 339.1 | 136.8 | 270.0 | 222.3 | 100.6 |
| 1974 | 429.5 | 179.8 | 320.2 | 283.1 | 129.3 |
| 1975 | 493.7 | 243.1 | 365.2 | 336.0 | 154.3 |
| 1976 | 574.1 | 237.9 | 416.6 | 378.9 | 186.3 |
| 1977 | 681.3 | 252.1 | 483.4 | 430.0 | 218.4 |
| 1978 | 736.1 | 329.2 | 502.2 | 505.8 | 185.7 |
| 1979 | 747.4 | 380.4 | 577.0 | 532.3 | 209.7 |
| 1980 | 913.0 | 410.5 | 714.3 | 696.1 | 269.7 |
| 1981 | 986.9 | 348.6 | 773.4 | 758.6 | 284.4 |
| 1982 | 1114.3 | 359.3 | 835.7 | 837.4 | 280.2 |
| 1983 | 1288.9 | 407.1 | 979.8 | 965.3 | 298.2 |
| 1984 | 1509.4 | 433.6 | 1150.4 | 1115.5 | 478.6 |
| 1985 | 1807.0 | 568.2 | 1409.5 | 1360.8 | 475.0 |

Source: NA data file of Bank Economic and Social Data Base.

Table 4 : Individual and Total Tax Revenues in Mauritius
(000'000)

| Year | Total Tax | Import Tax | Export Tax | Tax on Domestic transaction | Corporate Income Tax | Other Direct Taxes |
|---|---|---|---|---|---|---|
| 1965 | 200.4 | 56.2 | 12.9 | 35.4 | na | na |
| 1966 | 146.9 | 52.3 | 15.2 | 38.6 | 12.0 | 28.8 |
| 1967 | 161.5 | 56.6 | 13.4 | 41.8 | 13.8 | 35.9 |
| 1968 | 174.8 | 62.2 | 15.3 | 43.7 | 18.0 | 35.6 |
| 1969 | 182.6 | 64.1 | 14.6 | 47.8 | 17.6 | 38.5 |
| 1970 | 179.0 | 63.8 | 16.8 | 48.2 | 14.3 | 35.9 |
| 1971 | 204.2 | 73.8 | 18.7 | 50.1 | 23.2 | 38.4 |
| 1972 | 234.2 | 86.6 | 19.6 | 55.7 | 24.7 | 47.6 |
| 1973 | 313.0 | 107.1 | 29.9 | 82.9 | 36.2 | 56.9 |
| 1974 | 439.8 | 141.6 | 48.2 | 108.1 | 59.1 | 82.8 |
| 1975 | 660.0 | 187.8 | 129.8 | 123.0 | 92.5 | 126.9 |
| 1976 | 946.5 | 260.5 | 126.1 | 136.3 | 138.8 | 284.8 |
| 1977 | 1072.9 | 349.1 | 124.9 | 173.3 | 224.0 | 201.6 |
| 1978 | 1109.5 | 412.7 | 139.8 | 220.2 | 132.2 | 204.6 |
| 1979 | 1260.7 | 469.9 | 145.2 | 271.1 | 128.4 | 246.1 |
| 1980 | 1601.5 | 647.4 | 287.3 | 319.8 | 118.5 | 228.5 |
| 1981 | 1801.1 | 718.4 | 268.2 | 373.4 | 180.9 | 260.2 |
| 1982 | 1953.4 | 701.0 | 377.8 | 420.7 | 162.7 | 291.2 |
| 1983 | 2436.5 | 1001.1 | 416.4 | 538.9 | 146.9 | 333.2 |
| 1984 | 2802.7 | 1174.4 | 442.0 | 667.4 | 154.3 | 364.6 |
| 1985 | 2993.0 | 1375.7 | 369.9 | 716.2 | 134.9 | 396.3 |
| 1986 | 3502.3 | 1740.6 | 459.3 | 788.1 | 169.0 | 345.3 |

Sources: NA data file of Bank Economic and Social Data Base; GFS data file of IMF; Country Economic Memoranda, World Bank; and Recent Economic Development Report, IMF.

Table 5 :Individual and Total Tax Bases in Mauritius
(000'000)

| Year | GDPmp | Import | Private consumption | Export | Value Added in Non-Ag. |
|---|---|---|---|---|---|
| 1965 | 976.3 | 435.0 | 799.8 | 933.3 | 393.0 |
| 1966 | 963.0 | 402.0 | 814.1 | 927.6 | 392.0 |
| 1967 | 1024.1 | 435.0 | 842.9 | 984.7 | 378.0 |
| 1968 | 1011.2 | 479.0 | 870.4 | 988.6 | 452.0 |
| 1969 | 1088.0 | 449.0 | 863.5 | 1047.7 | 475.0 |
| 1970 | 1099.8 | 515.0 | 924.6 | 1063.2 | 531.0 |
| 1971 | 1218.4 | 583.0 | 1042.0 | 1165.8 | 523.0 |
| 1972 | 1516.7 | 722.0 | 1165.6 | 1415.7 | 759.0 |
| 1973 | 1951.1 | 1037.0 | 1441.0 | 1803.0 | 991.0 |
| 1974 | 3471.8 | 1902.0 | 2237.7 | 2784.3 | 2124.0 |
| 1975 | 3563.4 | 2227.0 | 2466.0 | 3233.8 | 2269.0 |
| 1976 | 4181.1 | 2712.0 | 2956.0 | 3766.0 | 2388.0 |
| 1977 | 4794.7 | 3235.0 | 3658.0 | 4503.0 | 2656.0 |
| 1978 | 5485.3 | 3477.0 | 4249.0 | 5281.0 | 2705.0 |
| 1979 | 6753.8 | 4158.0 | 5144.0 | 6416.0 | 3260.0 |
| 1980 | 7442.5 | 5342.0 | 6562.0 | 7783.0 | 4450.0 |
| 1981 | 8849.0 | 5634.0 | 7277.0 | 8952.0 | 4566.0 |
| 1982 | 10225.5 | 5859.0 | 8301.0 | 10195.0 | 5529.0 |
| 1983 | 10806.6 | 5999.0 | 8874.0 | 11298.0 | 5953.0 |
| 1984 | 12076.2 | 7470.0 | 9841.0 | 12624.0 | 6989.0 |
| 1985 | 14155.2 | 9210.0 | 11127.0 | 14494.0 | 8885.0 |
| 1986 | 15812.0 | 10515.0 | 12090.0 | 16405.0 | 11880.0 |

Source: The same as Table 4.

Table 6 : Generated Time Series on $\tau_i$s
in Malawi
(percentage)

| Year | Import Tax | Consumption Tax | Corporate Income Tax | Other Direct Taxes |
|---|---|---|---|---|
| 1965 | 8.35 | 1.77 | 5.64 | 2.07 |
| 1966 | 11.65 | 1.91 | 6.75 | 2.00 |
| 1967 | 15.28 | 1.26 | 9.47 | 2.12 |
| 1968 | 12.93 | 1.38 | 11.36 | 2.28 |
| 1969 | 15.05 | 2.32 | 12.56 | 2.93 |
| 1970 | 11.37 | 4.30 | 11.25 | 2.44 |
| 1971 | 11.44 | 5.43 | 11.85 | 2.18 |
| 1972 | 9.67 | 5.83 | 13.23 | 2.25 |
| 1973 | 8.97 | 6.10 | 11.70 | 2.29 |
| 1974 | 8.76 | 6.76 | 11.18 | 2.01 |
| 1975 | 7.07 | 6.82 | 14.98 | 2.02 |
| 1976 | 6.40 | 7.05 | 14.91 | 1.89 |
| 1977 | 7.46 | 7.60 | 15.58 | 1.96 |
| 1978 | 9.26 | 9.49 | 24.03 | 2.39 |
| 1979 | 10.24 | 11.24 | 20.94 | 2.67 |
| 1980 | 12.46 | 10.50 | 16.95 | 2.63 |
| 1981 | 18.30 | 10.88 | 13.90 | 2.64 |
| 1982 | 18.61 | 11.49 | 18.69 | 2.90 |
| 1983 | 18.27 | 11.39 | 20.76 | 2.97 |
| 1984 | 19.79 | 12.62 | 17.69 | 2.80 |
| 1985 | 21.31 | 11.38 | 25.24 | 2.46 |

Table 7 : Generated Time Series on $\tau_i$s in Mauritius

| Year | Import Tax | Consumption Tax | Corporate Income Tax | Other Direct Taxes |
|---|---|---|---|---|
| 1965 | 14.84 | 4.63 | - | - |
| 1966 | 14.69 | 4.98 | 3.39 | 2.69 |
| 1967 | 14.95 | 5.22 | 4.05 | 3.16 |
| 1968 | 15.20 | 5.29 | 4.53 | 3.15 |
| 1969 | 16.71 | 5.86 | 4.26 | 3.18 |
| 1970 | 14.59 | 5.50 | 3.12 | 2.93 |
| 1971 | 15.21 | 5.05 | 5.16 | 2.84 |
| 1972 | 14.66 | 5.02 | 3.86 | 2.86 |
| 1973 | 12.77 | 6.11 | 4.47 | 2.65 |
| 1974 | 9.20 | 5.08 | 3.42 | 2.23 |
| 1975 | 10.58 | 5.26 | 5.03 | 3.22 |
| 1976 | 12.28 | 4.84 | 7.21 | 6.15 |
| 1977 | 14.04 | 4.98 | 10.59 | 3.77 |
| 1978 | 15.66 | 5.47 | 6.24 | 3.33 |
| 1979 | 14.88 | 5.57 | 5.07 | 3.28 |
| 1980 | 16.19 | 5.13 | 3.41 | 2.68 |
| 1981 | 17.17 | 5.42 | 5.13 | 2.60 |
| 1982 | 15.98 | 5.35 | 3.80 | 2.53 |
| 1983 | 23.54 | 6.47 | 3.24 | 2.66 |
| 1984 | 22.02 | 7.29 | 2.93 | 2.59 |
| 1985 | 20.80 | 6.89 | 1.99 | 2.43 |
| 1986 | 23.53 | 6.98 | 1.84 | 1.87 |

## APPENDIX B: GENERALIZED VERSION OF THE MODEL

In Chapter II, all of the equations included in the model are assumed to have a specific functional form, i.e., semi-log linear. This assumption is relaxed in this annex and, hence, the generalized version of the model is discussed.

An individual tax yield assessed by tax inspectors is considered to be a function of $X_i$ and $\tau_i$, that is,

$$(T_i^*)_t = F_i[(X_i)_t, (\tau_i)_t] \qquad (1)$$

Let us assume that tax inspectors adjust actual tax revenues towards their assessed level according to a partial adjustment mechanism, that is,

$$\Delta(T_i)_t = \lambda_i[(T_i^*)_t - (T_i)_{t-1}] \qquad (2)$$

Then, the actual tax yield function is obtained by substituting (2) in (1), that is,

$$(T_i)_t = (1-\lambda_i)(T_i)_{t-1} + \lambda_i F_i[(X_i)_t, (\tau_i)_t] \quad \text{for } i=1 \text{ to } n \qquad (3)$$

where

$(\partial T_i/\partial X_i)$=coefficient of built-in flexibility of $T_i$ with respect to $X_i$ ($CBFX_i$),

$(\partial T_i/\partial \tau_i)$=own-DTMs direct response

Using the concept of the "realized individual tax rate" defined in Chapter II, its formula will have the following form after making a simple manipulation.

$$\tau_{it}=\left[ r_{it} \frac{1 + G_{it}}{1 + (CBFX_i)\dfrac{G_{it}(1+G_{it})}{r_{i0}+ G_{it}(CBFX_i)}} \right] \qquad (4)$$

where $r_{it}$ is average effective tax rate of $T_i$ at time "t" and

$$(G_i)_t=\ln(X_i)_t-\ln(X_i)_0 \qquad (5)$$

In its final form, each individual tax base is related to all $\tau_i$s and GDP, that is,

$$(X_i)_t = \Phi_i[(GDP)_t, (\tau_1)_t,\dots\dots\dots,(\tau_n)_t] \qquad (6)$$

where

$[(CBFX_i)(\rho X_i/\partial GDP)]$= coefficient of built-in flexibility of $T_i$ with respect to GDP ($CBFY_i$),

$(CBFX_i)(\partial X_i/\partial\tau_i)$= own-DTMs indirect response, and

$(CBFX_i)(\partial X_i/\partial\tau_j)$= cross DTMs indirect response.

Finally, the model is closed by adding the overall tax revenue identity, that is,

$$(T)_t=(T_1)_t+\dots\dots\dots+(T_n)_t \qquad (7)$$

Equations (3), (5), (6) and (7) perform the structural form of the model. Parameters of the model are estimated after substituting equation (4) in it.

After estimating $CBFY_i$s, the built-in tax elasticity of each individual tax with respect to GDP will be:

$$E_{it} = (CBFY_i)(GDP/AT_i)_t$$

where $AT_i$ is the adjusted tax revenue to discretionary tax changes obtained by simulating the model for $\tau_{it} = \tau_{i0}$.

## APPENDIX C: AN OPERATIONAL GUIDELINE ON THE APPLICATION OF THE MODEL

This appendix provides a brief guideline on the application of the model as an empirical framework for: (i) estimating tax elasticity and the revenue impact of DTMs, and (ii) evaluating the macroeconomic impact of a tax reform program aimed at generating additional revenue and/or dealing with various tax related economic issues which require converting the DTMs included in the reform to AETRNs and vice versa.

### i. Estimating Tax Elasticity and the Revenue Impact of DTMs

The structural form of the model is presented in Table 1. Estimates of its parameters are obtained by estimating the parameters of the model presented in Table 2. Estimating its parameters requires time series data on the following variables, which are readily available for most countries in GFS (an IMF publication) and the World Tables (a World Bank publication):

$T_d$ =Tax on domestic transactions

$T_m$ =Tax on imports

$T_c$ =Corporate income tax

$T_o$ =Other direct taxes

$T$ =Overall tax revenue net of export taxes

$X_d$ =Private consumption

$X_c$ =Value added in non-agriculture sector net out of wage bill

$X_m$ =Imports

$X_o$ =GDP

Table 1: Structural Form of the Model

$$\log(T_d)_t = \lambda_d\alpha_{d0} + \lambda_d\alpha_{d1}\log(X_d)_t + (1-\lambda_d)\log(T_d)_{t-1} + \lambda_d\alpha_{d2}(\tau_d)_t + U_{dt}$$

$$\log(T_m)_t = \lambda_m\alpha_{m0} + \lambda_m\alpha_{m1}\log(X_m)_t + (1-\lambda_m)\log(T_m)_{t-1} + \lambda_m\alpha_{m2}(\tau_m)_t + U_{mt}$$

$$\log(T_c)_t = \lambda_c\alpha_{c0} + \lambda_c\alpha_{c1}\log(X_c)_t + (1-\lambda_c)\log(T_c)_{t-1} + \lambda_c\alpha_{c2}(\tau_c)_t + U_{ct}$$

$$\log(T_o)_t = \lambda_o\alpha_{o0} + \lambda_o\alpha_{o1}\log(X_o)_t + (1-\lambda_o)\log(T_o)_{t-1} + \lambda_o\alpha_{o2}(\tau_o)_t + U_{ot}$$

$$\ln(X_d)_t = \beta_{d0}\ \beta_{d1}\ln(Y_d)_t + \beta_{d2}(\tau_m/\tau_d)_t + \upsilon_{dt}$$

$$\ln(X_m)_t = \beta_{m0} + \beta_{m1}\ln(GDP)_t + \beta_{m2}(\tau_m/\tau_d)_t + \beta_{m3}(\tau_c)_t + \upsilon_{mt}$$

$$\ln(X_c)_t = \beta_{c0} + \beta_{c1}\ln(GDP)_t + \beta_{c2}(\tau_c)_t + \beta_{c3}(\tau_m/\tau_d)_t + \upsilon_{ct}$$

$$\ln(T)_t = \delta_0 + \delta_d\ln(T_d)_t + \delta_m\ln(T_m)_t + \delta_c\ln(T_c)_t + \delta_o\ln(T_o)_t$$

$$\ln(Y_d)_t = \gamma_0 + \gamma_1\ln(GDP)_t + \gamma_2\ln(T_c)_t + \gamma_3\ln(T_o)_t$$

$$(\tau_m/\tau_d)_t = \theta_0 + \theta_1(\tau_m)_t + \theta_2(\tau_d)_t$$

where,

$T_d$= Tax on domestic transactions (endogenous variable),
$T_m$- Import tax (endogenous variable),
$T_c$= Corporate income tax (endogenous variable),
$T_o$= Other direct taxes (endogenous variable),
$X_d$= Private consumption (endogenous variable),
$X_m$- Imports (endogenous variables),
$X_c$= Value added in non-agriculture sector (endogenous variable),
$X_o$- GDP- gross domestic products (exogenous variable),
$\tau_i$- The $i^{th}$ individual realized tax rate (exogenous variable), for i= d, m, c, o,
$Y_d$= Disposable income (endogenous variable),
T= Total tax revenue net of export taxes (endogenous variable).

Table 2: Entire Model with Estimable Parameters*

$$\ln(T_d)_t = \lambda_d\alpha_{d0} + \lambda_d\alpha_{d1}\ln(X_d)_t + (1-\lambda_d)\ln(T_d)_{t-1} + \lambda_d\alpha_{d2}\left[r_d \frac{1+g_d}{1+\lambda_d\alpha_{d1}g_d}\right]_t + \varepsilon_{dt}$$

$$\ln(T_m)_t = \lambda_m\alpha_{m0} + \lambda_m\alpha_{m1}\ln(X_m)_t + (1-\lambda_m)\ln(T_m)_{t-1} + \lambda_m\alpha_{m2}\left[r_m \frac{1+g_m}{1+\lambda_m\alpha_{m1}g_m}\right]_t + \varepsilon_{mt}$$

$$\ln(T_c)_t = \lambda_c\alpha_{c0} + \lambda_c\alpha_{c1}\ln(X_c)_t + (1-\lambda_c)\ln(T_c)_{t-1} + \lambda_c\alpha_{c2}\left[r_c \frac{1+g_c}{1+\lambda_c\alpha_{c1}g_c}\right]_t + \varepsilon_{ct}$$

$$\ln(T_o)_t = \lambda_o\alpha_{o0} + \lambda_o\alpha_{o1}\ln(X_o)_t + (1-\lambda_o)\ln(T_o)_{t-1} + \lambda_o\alpha_{o2}\left[r_o \frac{1+g_o}{1+\lambda_o\alpha_{o1}g_o}\right]_t + \varepsilon_{ot}$$

$$\ln(X_d)_t = \beta_{d0} + \beta_{d1}\ln(Y_d)_t + \beta_{d2}\left[\frac{r_m[(1+g_m)/(1+\alpha_{m1}g_m)]}{r_d[(1+g_d)/(1+\alpha_{d1}g_d)]}\right]_t + \upsilon_{dt}$$

$$\ln(X_m)_t = \beta_{m0} + \beta_{m1}\ln(GDP)_t + \beta_{m2}\left[\frac{r_m[(1+g_m)/(1+\alpha_{m1}g_m)]}{r_d[(1+g_d)/(1+\alpha_{d1}g_d)]}\right]_t + \beta_{m3}\frac{r_c(1+g_c)}{(1+\alpha_{c1}g_c)} + v_{mt}$$

$$\ln(X_c)_t = \beta_{c0} + \beta_{c1}\ln(GDP)_t + \beta_{c2}\left[r_d \frac{1+g_d}{1+\alpha_{d1}g_d}\right]_t + \beta_{c3}\left[\frac{r_m(1+g_m)/(1+\alpha_{m1}g_m)}{r_d(1+g_d)/(1+\alpha_{d1}g_d)}\right]_t + \upsilon_{ct}$$

$$\ln(T)_t = \delta_0 + \delta_d\ln(T_d)_t + \delta_m\ln(T_m)_t + \delta_c\ln(T_c)_t + \delta_o\ln(T_o)_t$$

$$\ln(Y_d)_t = \gamma_0 + \gamma_1\ln(GDP)_t + \gamma_2\ln(T_c)_t + \gamma_3\ln(T_o)_t$$

$$g(i)_t = \ln(X_i)_t - \ln(X_i)_0 \qquad \text{for } i=d,\ m,\ c,\ o$$

* Estimating the parameters of the model requires time series data on $T_i$s, T, $X_i$s, $r_i$s and GDP which are readily available for most LDCs in GFS(an IMF publication) and World Tables (a World Bank publication).

$Y_d$=Disposable income

$r_i$=The $i^{th}$ individual average effective tax rate (T/X),

for i=d, m, c, o, and

GDP= Gross domestic product.

Using these time series data, the efficient and consistent estimates of the parameters of the model presented in Table 2 are obtained by means of a simultaneous-equation econometric technique.

A within-sample dynamic simulation is performed for all the endogenous variables included in the model in order to generate time series data on $g_i$s. Using this data and estimates of $\lambda_i$s and $\alpha_i$s, time series data on $\tau_i$s are generated by means of the following equation.

$$(\tau_i)_t = \left[ (r_i)_t \frac{(1 + g_i)_t}{(1 + \lambda_i \alpha_{i1} g_i)_t} \right]$$

The generated time series data on $\tau_i$s can be used independently to explore the impact of changes in each individual tax system on key macroeconomic variables such as inflation, economic growth, budget deficit, real exchange rate and international balance of payments. To linearize the structural form of the model presented in Table 1, these data are used to estimate the parameters of the following deterministic equation, in other words, to linearize ($\tau_m/\tau_d$) using one of the techniques discussed in the text as follows.

$$(\tau_m/\tau_d)_t = \theta_0 + \theta_1(\tau_m)_t + \theta_2(\tau_d)_t$$

Now, by substituting the estimated value of the parameters in the original equations of the model presented in Table 1, the structural form of the model with estimated parameters (SFM) is obtained.

The short run and the long run elasticities of individual tax yields and base and overall tax revenue with respect to GDP, and the direct and indirect responses of each individual tax yield to the changes in its own and other individual tax systems are simply obtained either by substituting the estimated parameters into the formulas presented in Tables 3 to 7 of the text or by directly solving the SFM as an ordinary and a difference equations systems and, hence, deriving the reduced (RFM) and final (FFM) forms of the model.[1]

<u>ii. Evaluating/Designing A Quantitative Tax Reform Program</u>

The reduced/final form of the model can be used as an empirical framework to evaluate the short run/long run macroeconomic impact of a tax reform program and to forecast a government's revenues from various sources of taxation. However, this requires converting the proposed DTMs to $\tau_i$s or vice versa. An example from Malawi is considered to illustrate how to convert the proposed DTMs to $\tau_i$s and vice versa.

Let us assume that the Malawian government wants to raise total tax revenue by 5.67 percent using statutory surtax rate (SSR) as a policy instrument. Then, the questions are: How much of an increase in the surtax rate will result in a 5.67 percent increase in total tax revenue? And what is the macroeconomic impact of this discretionary tax measure? Answering these questions requires quantitative knowledge on the impact of a one percentage point increase in SSR on both its corresponding and other

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1/ For more details on solution of a dynamic macroeconometric model see Ehdaie (1987).

individual tax yields and bases. Providing such information, first of all, requires converting a one percentage point increase in SSR to $\tau_d$.

In this country, surtax was introduced in 1970/71 at a statutory tax rate of 18 percent. Then, this rate was increased to 25 percent in 1983/84. Given one of these DTMs, say the former, and time series data on $\tau_d$, the amount of increase in $\tau_d$ due to a one percentage point increase in SSR is calculated as follows. As a result of introducing surtax in 1970 (fiscal year 1970/71), $\tau_d$ rose from 2.32 percent in 1969 to 4.30 percent in 1970 (see Table 6 in Appendix A). Given 18 percent SSR, $\tau_d$ went up by 0.111 percentage points due to a one percent point increase in SSR (the same result is obtained using the DTMs of 1983/84).

It is apparent from the coefficient of $\tau_d$ in the overall tax equation presented in Table 11 of the text that total tax revenue will rise by 5.67 percent as result of a one percentage point increase in $\tau_d$, whose equivalent is a 9 percentage point increase in the statutory surtax rate. In other words, the new SSR will be 34 percent (25 percent plus 9 percent) which will result in a 5.67 percent increase in overall tax yield.

Using the coefficients of $\tau_d$ in the other equations included in the model presented in Table 11 of the text, the macroeconomic impact of this discretionary tax measure will be as follows. First, tax on imports and domestic transactions will increase by 0.73 and 18.81 percent respectively. Second, corporate income tax will decline by 0.11 percent. Third, private consumption and value added in the non-agriculture sector of the economy will fall by 0.65 and 0.13 percent respectively, and finally, imports will rise by 0.81 percent.

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